

contaminants, and if they remain viable then there is little need to monitor other components. In cases where animals or plants are continuously re-contaminated from an invisible or unknown source it may be appropriate to attempt to monitor the pathway of oil contamination. However, reliable interpretation of analytical data from sediment samples can be difficult if there is a wide range of other contaminants present.

Costs and compensation

When it proves impossible to protect fishing gear and cultivation facilities from oil contamination, the choice becomes one of cleaning, repairing, restoring or replacing the affected item, facility or habitat. In some situations compensation arrangements may exist, allowing fishermen and aquaculture operators to be reimbursed for costs incurred and losses suffered. Claimants will be expected to provide evidence of the losses, such as receipts of payments made and records of income in previous years.

The complexities of biological systems and business interactions often make it difficult to separate the actual impact of an oil spill from other influences. Reliable catch statistics are rarely available in sufficient detail to enable oil spill effects to be isolated from other influences such as variable fishing effort and natural fluctuations in the stock. Only with expert knowledge of local circumstances, careful investigation and comparisons with nearby unpolluted areas can the true causes of observed damage be determined. In the case of subsistence fishing no financial transactions may be involved, so catch records are unlikely to be available. However, it should be possible to quantify subsistence loss in bartering terms or with other market-based substitutes.

Economic loss resulting from mortality of cultivated organisms may need to be quantified at several levels. The first level is the immediate mortality and loss suffered by the grower. This may simply be a question of counting and weighing the casualties, documenting any reduction in growth rate, and calculating any financial losses from projected harvests and from closed or under-utilized aquaculture facilities. Depending on the magnitude of the event and the availability of suitable substitutes, losses may also be suffered by processors, transporters, wholesalers and retailers. In a large or notorious incident actual or perceived tainting may result in short and long-term loss of markets and reduced prices across broad geographic regions. Quantification of these impacts can be complicated and may involve not only the direct losses, but also the advertising costs incurred to limit the harm to a region's reputation.

Management strategies for protecting seafood resources

The simplest management strategies involve no intervention beyond monitoring the evolution of an oil spill and any threat to seafood safety. Low-key intervention can take the form of advisory information or the issuing of guidelines to the seafood industry. Stricter measures include retail controls, impoundment of catches and seafood products, activity bans and fishery closures.

All management options have drawbacks or indirect effects and a careful review of the various facets of an oil spill is to be recommended before any actions are taken. Commercial fishing creates complex changes in the abundance and distribution of the exploited species. Any sudden change in the fishing effort is therefore likely to affect population densities. Thus, while most oil spill management strategies undoubtedly cause business interruption and financial loss, some fishery closures have also resulted in beneficial stock conservation, particularly where the exploited species have been non-migratory.

Preferred management strategies reflect cultural and administrative traits in different countries. In Asia there are few reported instances of tainting or seafood contamination following oil spills. Formal closures or activity bans are seldom, if ever, introduced. Instead voluntary suspension of fishing in oil-polluted areas is the norm. The voluntary suspension typically lasts a few weeks until the gross oil contamination of shorelines has disappeared or has been removed. In most cases, fishing and harvesting are resumed without any ill effects in terms of tainting, public health or market confidence.

During an oil spill it is vital to communicate information to the media and the public in an effective manner on the likelihood of adverse consequences for fishery resources. Inaccurate public information about tainting and contamination may limit the range of management strategies available, causing unnecessary fishing and harvesting restrictions and/or loss of consumer confidence in the market. Risk communication is an ongoing process that must be addressed in both spill response planning as well as during the spill event. Information about risk can be communicated through a variety of channels, from media reports to public meetings. Several resources provided in [Appendix F](#) can provide further information on successfully communicating risk to the media and public.

The media can play a valuable role in promoting a rational reaction to temporary disruptions. For example, where a properly conducted sampling and testing regime provides clear evidence that seafood is safe, the media provides the vehicle for getting this message to the consumer. The needs of the media are best served by providing factual information and by clearly justified decisions. Contingency planning provides the best opportunity for managers to select an appropriate strategy and implement the most effective response for dealing with a threat to seafood safety and quality.

Fishing and aquaculture procedures

In addition to standard spill response measures, there are management options that may help minimize contamination and financial losses. Options include moving floating facilities out of the path of slicks, sinking of specially designed cages to allow oil to pass, and transfer of stock to areas unlikely to be affected. The opportunities to use these approaches are likely to be rare for a range of technical, logistical and cost considerations, but in the right circumstances and with planning they may be practicable.

Temporarily suspending the replenishment of seawater drawn in from the sea and re-circulating water already within the system may be an effective method of isolating stock cultivated in shore tanks or ponds from the threat of oil contamination. Closing sluice gates to prawn ponds, for example, can also afford short-term protection, but care must be taken to ensure that the build-up of noxious waste products in stagnant or re-circulating water over time does not cause mortalities. Suspension of feeding is another way of reducing the risk to farmed fish and other cultivated stock from coming into contact with floating oil or contaminated feed. In land-based facilities the reduction or suspension of feeding has the advantage that the loading of waste products in the re-circulated water is reduced.

For such measures to be effective it is vital that sensitive fishing and aquaculture facilities are identified in local area contingency plans and that key personnel are notified in the event of an oil spill in their area. The plans can also identify optimal response options and the sources of necessary materials and equipment. The preparation and maintenance of such plans are normally the responsibility of local government authorities or operators of local oil-handling facilities.

In some cases aquaculture operators may face the risk of ultimately losing all the stock due to oil spill damage. Harvesting before the stock becomes oiled might be possible, albeit selling the products at a lower price, and thereby salvaging some of its value. Conversely, normal harvesting could be delayed to allow contaminated stock to depurate and become taint-free.

Where fish are caught by anglers for sport, sufficient protection can sometimes be provided simply by issuing advice against consuming the catch and for recreational fishermen to adopt a catch-and-release policy.

Fishing and harvesting restrictions

Government restrictions on fishing activity are often unrelated to oil spills and are imposed as a means of stock conservation or to ensure fair competition among fishermen. Fishing may be restricted to certain periods and locations, with closures often coinciding with breeding seasons and sites to encourage natural stock replenishment. Catches may be restricted to certain quantities or quotas in a given period. Temporary closures of

fisheries are imposed to protect consumers from health hazards when water and sediment quality or a seafood resource has become degraded by pollutants, natural toxicants or microorganisms.

Fishery closures can be imposed after an oil spill in order to prevent or minimize fishing gear contamination and to protect or reassure seafood consumers. Fishermen can agree to a voluntary suspension of fishing activity as a precautionary measure during a period when oil is drifting in their normal fishing area, and thereby avoid repeatedly contaminating fishing gear. Alternatively, a fishery may be protected by extending existing closures or imposing additional bans, but there are likely to be secondary consequences from all these measures.

Fishery closures imposed to protect equipment and catches can generally be lifted once the sea surface is visually free of oil and sheen, and there is no problem with sunken oil. Aerial surveillance is the most reliable way of checking sea surface conditions. Restrictions imposed on the basis of proven tainting are likely to be more prolonged and require careful monitoring. In most oil spill scenarios a fisheries and aquaculture management protocol consisting of a visible-sheen test and sensory tests will satisfy the demand for scientific credibility and provide adequate safeguards against unpalatable and unsafe seafood reaching consumers.

Credible decision-making with respect to fishing and harvesting restrictions should be based on sound scientific principles and common sense. Knowledge of fishery resource management is essential, as is an understanding of oil pollutants, their physical and chemical characteristics, likely biological impact, and background levels of contamination, both locally and nationally. Seafood consumption patterns and seasonal variations in trading and marketing will further help define a public health risk profile and allow regulators to form a considered opinion on risk management. It is vital to determine the criteria that will be applied for reopening a fishery before a ban is put in place. These criteria form an important part of contingency plans. It is also critical to assess the benefits accruing as a result of a closure against the losses that will ensue from closing or restricting normal fishing and cultivation activity.

Conclusions and recommendations

Oil spills can pose a significant threat to fishing and aquaculture resources. The main oil pollution effects are physical contamination of equipment, tainting and contamination of seafood, and economic loss from business interruption, including loss of consumer confidence. With effective contingency plans and spill response procedures, much can be done to prevent or reduce the impact of oil spills on fishing and aquaculture.

The repercussions of contaminated seafood on public perception can be serious unless the issues of market confidence and public health are properly managed. In most cases a management protocol consisting of a visible-sheen test coupled with sensory testing will provide adequate safeguards against unpalatable and unsafe seafood reaching consumers.

To maintain confidence in the fisheries sector there should be a sound strategy for implementing a fishery closure, based on scientific data, and a consistent application of management restrictions. An important component of oil spill contingency considerations is the need to determine re-opening criteria before deciding on whether to impose fishing and harvesting bans. Part of the rationale for introducing fishery closures is to minimize or prevent economic damage that might otherwise occur, as well as protecting the consumer. In such cases some form of economic appraisal is necessary in order to monitor the effectiveness of control measures from a cost-benefit viewpoint.

G.2 Decision Process for Managing Seafood Safety

The default position regarding management of seafood safety during an oil spill is to have no closure or other restrictions on seafood harvest. In some cases there may be an initial, temporary *de facto* closure if the U.S. Coast Guard establishes a safety zone restricting access in areas of active oil recovery. Fishermen also may voluntarily avoid working in oiled areas to prevent oiling their gear and catch. This initial period after a spill can provide an opportunity to evaluate spill conditions and conduct limited testing to determine whether a precautionary closure or other immediate restrictions on seafood harvest are warranted.

The first step for seafood managers after an oil spill has occurred is to collect and evaluate information on the nature of the spill. The spill response organization should be able to provide the following information almost immediately after the spill occurs:

- Overflight maps and trajectory analyses showing the present and predicted spread of surface slicks;
- Forecasts of weather and sea conditions that may affect the potential for oil to mix into the water column;
- Results of oil weathering models;
- Details about the oil type and expected behavior;
- Predictions of oil fate and persistence; and, some cases,
- Chemical results for water and sediment samples collected in the spill area.

Fishery management agencies and associations should be able to provide information on:

- Species being harvested now or in the near future;
- Geographical extent of the harvest areas;
- Harvest gear types in use; and,
- Data on background levels of PAH contamination in the spill area (from NOAA, California State Mussel Watch, and other monitoring programs).

Based on this information, seafood managers can assess whether the oil spill is likely to expose and contaminate seafood. If seafood is not at significant risk, then no harvest closures or other seafood restrictions are needed, and this determination is communicated to the public. Because spills are dynamic, conditions are monitored and risks to seafood reevaluated until the threat abates.

If managers determine that seafood may be affected, the next step is to assess whether seafood is tainted or contaminated to levels that pose a consumption risk to human health. Information that can help determine the impacts includes:

- Overflights and ground surveys identifying visible oil in seafood harvesting areas;
- Chemical analysis of water and/or sediment samples from the harvest area;
- Sensory testing of seafood samples from representative species and areas (both spill and reference areas);
- Chemical analysis of tissue samples from representative species and areas (both spill and reference areas); and,
- Data on background levels of oil-related contaminants.

Determining whether seafood has been contaminated can take time. Developing and implementing sampling plans, conducting sensory and/or chemical testing, and evaluating results may require weeks or longer. Monitoring continues and the risk assessment process is repeated as necessary.

If seafood is tainted or is contaminated to a level posing a potential health risk, the next step is to select the most appropriate seafood management action(s). Examples of management actions include seafood advisories,

increased inspections of harvested seafood or fishing gear, harvest closures, and fishing gear restrictions. If a fishery is closed or otherwise restricted, seafood managers must establish criteria for determining when the seafood is palatable and safe for human consumption and that restrictions can, therefore, be lifted. No accepted international or federal criteria have been established for oil-related contaminants in seafood. State seafood managers generally have developed their own criteria for each spill, resulting in some inconsistencies among spills. Varying levels of background contamination also have contributed to inconsistencies in criteria applied.

Seafood Safety Management Authority

Typically, authority to manage seafood to protect human health resides with state health agencies. Many states routinely chemically analyze finfish and shellfish tissues for contamination as part of their water-quality monitoring programs. If a state concludes that eating contaminated finfish or shellfish collected from state waters poses an unacceptable human health risk, it may issue local fish consumption advisories or harvest closures for specific water bodies or parts of water bodies and specific species.

The Food, Drug, and Cosmetic Act authorizes the U.S. Food and Drug Administration (USFDA) to protect and promote public health. The USFDA's responsibilities include keeping "adulterated" food off the market. The USFDA has jurisdiction over seafood that crosses state lines in interstate commerce.

The Magnuson Act, 16 U.S.C. 1801 *et seq.*, authorizes NOAA's National Marine Fisheries Service (NMFS) to regulate fishing in federal waters (generally from 3-200 miles from shore). The act is targeted toward fishery conservation rather than protection of public health or economic concerns. Fishery management plans, developed under the authority of the Magnuson Act, specify any limitations imposed on fishing for federally regulated species. Limits on fishing are enforced by means of regulations published in the Federal Register, in compliance with the Administrative Procedures Act. In the event of an oil or chemical spill, publication of an emergency rule in the Federal Register is required to put an enforceable, official fishery closure in place and to make any modifications to the closure once it is put into effect. The Magnuson Act was recently amended to allow emergency action fisheries closures to remain in effect indefinitely. Previously, such closures were limited to two 90-day periods.

Specific Seafood Contamination Terminology

Adulteration

According to the U.S. Food and Drug Administration (FDA), a food is considered adulterated if it bears or contains any poisonous or deleterious substance that may render it injurious to health, if it contains any filthy, putrid, or decomposed substances, or if it is otherwise unfit for food (Federal Food, Drug, and Cosmetic Act, Section 402).

Taint

Taint is commonly defined as an odor or flavor that is foreign to a food product, including seafood (ISO 1992). According to this definition, the presence of a taint simply indicates that flavor or odor is altered; it does not characterize the nature of the off-flavor or off-odor, quantify the degree of taint, or imply health hazard.

Body Burden

The concentration of a contaminant in an organism, reported for the whole animal, or for individual tissues such as gonads, muscle, and liver, is referred to as the body burden. It can be reported on the basis of either wet or dry weight of the organism or tissue.

Uptake

Uptake is the process of contaminant accumulation in an organism. Uptake of oil can occur via the following mechanisms:

- Adsorption (adhesion) of oil on the skin.
- Absorption of dissolved components from the water through the skin (including interstitial water exposures for infauna).
- Absorption of dissolved components through the gills.
- Adsorption of dispersed oil droplets to the lipid surfaces in the gills.
- Ingestion of whole oil droplets directly or of food contaminated with oil, followed by sorption in the gut.

Many factors influence uptake, including the exposure concentration and duration, pathway of exposure, lipid content, and feeding and metabolic rates. Uptake from water generally occurs more quickly than dietary uptake or uptake from sediments.

Bioaccumulation

The net accumulation of a substance by an organism as a result of uptake from all environmental sources and possible routes of exposure (contact, respiration, ingestion, etc.) is termed bioaccumulation.

Bioconcentration

The net accumulation of a substance as a result of uptake directly from aqueous solution.

Biomagnification

The increase in body burden of a contaminant with trophic level is called biomagnification. PAHs generally do not biomagnify in finfish and shellfish because of their low dietary uptake efficiencies, on the order of 1 to 30%, reflecting slow kinetics and short residence time in the gut.

Elimination

All of the processes that can decrease tissue concentrations of a contaminant, including metabolism, excretion, and diffusive loss are collectively termed elimination. *Metabolism* is an active physiological process whereby a contaminant is biotransformed into metabolites. For PAHs, the metabolites are more water-soluble, which facilitates *excretion*, another active physiological process that eliminates contaminants (both parent compounds and metabolites) through bile, urine, or feces. *Diffusive loss* refers to a decrease in tissue burden caused by simple diffusion out of the organism, which is controlled by partitioning between tissue and water. The term *depuration* may be used for the mechanism of diffusive loss, and *elimination* may be used for the combined process of metabolism, excretion, and diffusive loss. These definitions are slightly different than those used by ASTM (1994), which defines depuration as “the loss of a substance from an organism as a result of any active or passive process” and provides no definition for elimination. However, the definitions given are more precise and will be followed in this document. Elimination can also include release of PAHs in lipid-rich eggs or gametes during spawning.

Elimination processes begin as soon as uptake occurs. In constant exposure experiments, body burdens tend to reach a “steady state” in which fluxes of the contaminant moving bi-directionally across a membrane or boundary between compartments or phases have reached a balance, not necessarily equilibrium. When the exposure decreases, elimination rates depend, in part, on the hydrophobic properties of the compound. The half-lives of individual compounds vary (see discussion below).

Growth Dilution

Growth dilution occurs when the rate of tissue growth exceeds the rate of accumulation, such that it appears as though elimination is occurring because the tissue concentration is decreasing. This process may be important when monitoring bivalves during the growing season.

Oils have been grouped into types with similar properties to help predict their behavior at spills. This same approach can be used to characterize the relative risk of contamination of seafood by oil type. Table II-2 summarizes the properties and risk of seafood contamination for the five oil groups commonly encountered by spill responders. These generalizations can be used when initially screening an incident to evaluate the potential for seafood contamination.

ASSESSING THE LIKELIHOOD OF SEAFOOD EXPOSURE AND CONTAMINATION

Each oil spill is a unique combination of conditions and events. Seafood is only at risk of contamination from a spill if it is exposed to the oil. Once exposed to oil, an organism becomes contaminated only to the extent it takes up and retains petroleum compounds. Factors that influence the potential for spilled oil to expose and contaminate seafood are discussed in this section.

Oil Types and Properties

Oil type and properties strongly influence whether seafood is exposed and contaminated. Crude oils and the refined products derived from them are complex and variable mixtures of hydrocarbons of different molecular

weights and structures. They can contain hundreds of different compounds. All crude oils contain lighter fractions similar to gasoline, as well as heavier tar or wax fractions. Because of these differences in composition, different oils vary considerably in their physical and chemical properties. For example, consistencies of different crude oils vary, ranging from a light volatile fluid to a viscous semi-solid. Such differences in properties influence behavior of spilled oil and subsequent cleanup operations.

The petroleum hydrocarbons that comprise oil are composed primarily of hydrogen and carbon, but also can contain varying amounts of sulfur, nitrogen, oxygen, and trace metals. The three main fractions of hydrocarbon compounds in oils are saturates, aromatics, and polar compounds. The table below shows the properties and relative abundance of each fraction in different types of oil products.

Seafood contamination can result from exposure to the dissolved fraction of oil, dispersed oil droplets, or an oil coating. With regard to the dissolved fraction, the aromatic fraction of the oil poses the greatest exposure risk because aromatics are relatively more soluble than the other components in oil. Saturates are a major component of oil, but they have lower solubility and higher volatility compared to aromatics of the same molecular weight. Furthermore, saturates are virtually odorless and tasteless, and do not contribute to tainting.

Table G.2-1 Characteristics of oil types affecting the potential for seafood contamination

Gasoline products	Diesel-like products and light crude oils	Medium-grade crude oils and intermediate products	Heavy crude oils and residual products	Non-floating oils
Examples – Gasoline	Examples – No. 2 fuel oil, jet fuels, kerosene, West Texas crude, Alberta crude	Examples – North Slope crude, South Louisiana crude, IFO 180, lube oils	Examples – San Joaquin Valley crude, Venezuelan crude, No. 6 fuel oil	Examples – Very heavy No. 6 fuel oil, residual oils, vacuum bottoms, heavy slurry oils
Specific gravity of < 0.80 Floats on surface	Specific gravity of < 0.85; API gravity of 35-45* Usually floats on surfaces, although can contaminate suspended sediments that are then deposited on the bottom.	Specific gravity of 0.85-0.95; API gravity of 17.5 – 35 * Usually floats on surface, although can mix with sand by stranding on beaches or in the surf zone, and be deposited in the nearshore area.	Specific gravity of 0.95 – 1.00; API gravity of 10-17.5 * Usually floats on surface but can sink in fresh water or in seawater if they emulsify or mix with sand (in the surf zone or after stranding on beaches) and deposit in the nearshore.	Specific gravity greater than 1.00; API gravity < 10 * Will sink in fresh water; may sink in seawater if they emulsify or mix with sand (in the surf zone or after standing on beaches) and deposit in the nearshore.
High evaporation rates; narrow cut fraction with no residues.	Refined products can evaporate to no residue; crude oils do leave residues.	Up to one-third will evaporate in the first 24 hours; will form persistent residues.	Very little product loss by evaporation; will form persistent residues.	Very little evaporation when submerged; also very slow weathering overall when submerged.
Low viscosity; spreads rapidly to a thin sheen; readily dispersed; will not emulsify.	Low to moderate viscosity; spread rapidly into thin slicks; readily dispersed by natural processes; may form unstable emulsions.	Moderate to high viscosity; dispersed by natural processes only very early in the spill; readily emulsifies.	Very viscous to semisolid; will not readily disperse or mix into the water column; can form stable emulsions.	Very viscous to semi-solid; will not readily disperse or mix into the water column; can form stable emulsions.
Low risk of seafood contamination because of rapid and complete loss via evaporation; potential contamination for spills in confined areas with high mixing, such as small rivers; no reported cases of tainting for marine spills.	Moderate to high risk of seafood contamination because relatively high content of low molecular weight, water-soluble aromatic hydrocarbons, which are semi-volatile and so evaporate slowly; dispersed droplets are also bio-available.	Moderate to high risk of seafood contamination because of high percentage of low-molecular weight aromatic hydrocarbons; coating of gear and intertidal species can be significant.	Low risk of finfish contamination because of low water-soluble fraction and little natural mixing in the water; moderate to high risk of shellfish contamination where shoreline oiling is heavy; can coat gear and intertidal species.	Low risk of finfish contamination because of high viscosity; where thick oil accumulates on the bottom, could become a chronic source; moderate to high risk of contamination of benthic species because of coating and persistence of submerged oil.

* API gravity is used by the petroleum industry rather than density. It is determined by the following equation: $API \text{ at } 60^{\circ}F = 141.5 / \text{oil density} - 131.5$

Of the aromatic hydrocarbons, the mono-aromatic hydrocarbons, such as benzene, toluene, ethyl benzene, xylene (known collectively as BTEX), other substituted benzenes, and the 2- to 3-ringed PAHs (naphthalene, fluorene, dibenzothiophene, anthracene and their substituted homologues, referred to as low-molecular weight

PAHs) comprise over 99 percent of the water-soluble fraction. The distribution of these compounds in the spilled oil is one measure of the potential for contamination of seafood from water exposure.

Compounds in petroleum-derived oils have a general pattern of increasing abundance with higher level of substitution of a benzene ring (*e.g.*, unsubstituted parent naphthalene is less abundant than C1-naphthalene, which is less abundant than C2-naphthalene). This pattern indicates that the PAHs are “petrogenic,” that is, they are from petroleum oils. The PAH pattern is very different for hydrocarbons produced from the combustion of fossil fuels (“pyrogenic” hydrocarbons), in that the parent PAHs are by far the dominant compounds in hydrocarbons of pyrogenic origin. Also, it is important to note that crude oils contain very low concentrations of the high-molecular weight PAHs (*e.g.*, 4- and 5-ringed compounds such as pyrene, chrysene, and benzo[a]pyrene) that are associated with combustion by-products. These differences in relative PAH abundance are key components of fingerprinting analysis.

Refined products have characteristic ranges of PAHs representative of the distillation fraction in the product. PAHs in No. 2 fuel oil are dominated by the 2- and 3-ringed compounds. Heavy fuel oils are sometimes cut or blended with lighter fractions to meet customer specifications, as is the case with the intermediate fuel oil (IFO-180), and so can contain some low-molecular weight PAHs.

For exposure via ingestion of whole oil droplets or contaminated sediments, the high-molecular weight PAHs pose greater risk of contamination. These compounds have low water solubility and are more lipophilic. In organisms with relatively limited capability to metabolize PAHs, such as bivalve mollusks, the high-molecular weight compounds are more likely to accumulate in tissues and persist for longer periods, compared to the low-molecular weight PAHs, which are more rapidly eliminated. Finfish and some crustaceans, however, readily metabolize and eliminate all of these compounds rapidly.

Biological and Ecological Factors Affecting PAH Contamination of Seafood

Petroleum contamination of finfish and shellfish depends upon a variety of biological and ecological factors. Understanding how different feeding strategies, habitat utilization, and physiology influence the likelihood of petroleum contamination of particular species is critical when managing seafood after spills. G.2-2 summarizes several of these factors for different types of seafood organisms.

Metabolic Capacity

Both vertebrates and invertebrates have mixed-function oxygenase (MFO) enzyme systems that enable them to metabolize petroleum substances. Enzymatic activity is low in invertebrates compared to vertebrates, and therefore induction of metabolism occurs at a higher contamination level in invertebrates. Finfish are able to rapidly and efficiently biotransform or metabolize PAHs and excrete the resulting metabolites into bile. These metabolites do not pose a health risk to human consumers of the finfish. Marine invertebrates, including most shellfish, metabolize petroleum compounds slowly and inefficiently; consequently, they tend to accumulate high concentrations and wide ranges of PAHs.

Metabolic capacity of organisms is important from a seafood safety standpoint because some PAHs have carcinogenic potential for human consumers, due to the highly chemically reactive oxidation products that form during the first stage of metabolism in vertebrates. Human consumers often eat invertebrates in their entirety, and, therefore, may ingest all of the hydrocarbons that have accumulated in the organism and may be present in the organism’s gut. Because finfish, like other vertebrates, rapidly and efficiently metabolize petroleum hydrocarbons, they generally pose little or no health risk to human consumers. Exceptions to this may occur for consumers for whom the edible portion of finfish includes tissues such as liver and gall bladder, which tend to accumulate higher levels of PAHs than muscle tissue.

Temperature

It is generally accepted that uptake and elimination rates both tend to increase with increasing temperature, though there is some contradiction among reported study results for PAHs.

The rate of reaction in chemical and biological processes generally increases 2- to 4-fold for a 10°C increase in temperature. Uptake, metabolic, and elimination rates typically increase with temperature, but at different rates, making it difficult to predict body burdens under the constantly changing oil concentrations that occur at spills. However, at high temperatures and increased respiration and filtration rates, it is expected that uptake will occur quickly, to relatively high concentration, followed by rapid declines. At low temperatures, body burdens are likely to be lower, but elimination rates will also be slower. At very low temperatures, some species stop feeding and thus are at lower risk of exposure.

Table G.2-2 Habitat utilization, feeding strategies, and risk of exposure to oil of different seafood groups.

Seafood groups	Examples	Metabolic capacity	Habitat utilization	Feeding strategies	Risk of exposure
Finfish					
Anadromous fish	Sturgeon, herring, salmon	High capacity	Nearshore and shallow water during spawning	Predatory	Moderate to high in nearshore and shallow water during spawning
Marine pelagic and bottom fish	Mackerel, jacks, cod, flounder	High capacity	Highly mobile, most species prefer depths of > 10m	Predatory	Low
Reef fish	Sea basses, snappers, porgies	High capacity	Relatively deep waters (10 – 200 m)	Predatory	Low to moderate; higher risk in shallow water
Estuarine fish	Bluefish, mullet, anchovies	High capacity	Spawning in intertidal or subtidal habitats; offshore winter migrations	Predatory	Moderate to high in nearshore and shallow water during spawning
Crustaceans					
Lobster, crabs, shrimp	American lobster, pink shrimp, blue crab	Reduced capacity	May migrate seasonally; range of depths between estuarine and deep waters.	Predatory; omnivorous, scavengers	Benthic burrowing, estuarine and shallow water species at higher risk than deep water species
Mollusks					
Oysters, mussels	American oyster, Pacific oyster, blue mussel	Very limited capacity	Shallow subtidal and intertidal regions, estuaries; attached to substrates	Filter-feeders	High
Clams, scallops	Hard clam, soft-shell clam, bay scallop, sea scallop	Very limited capacity	Intertidal and shallow subtidal areas; benthic or buried in the sediment; some mobility	Filter/deposit feeders	High
Gastropods	Abalone, conch, snails, whelk, limpet, top shell	Very limited capacity	Intertidal and shallow to deep subtidal areas; epibenthic; some mobility	Grazers and predatory	Moderate to high

Physiology

Lipid, carbohydrate, and protein levels are known to vary seasonally in certain aquatic invertebrate species, often associated with reproductive changes. Some of these changes in biochemical composition may affect uptake and elimination rates seasonally. Seasonal variation may also result from differences in feeding rates, microbial activity, and various environmental factors.

Organisms with higher overall lipid content generally exhibit higher levels of uptake or retention of petroleum compounds. For example, salmon (muscle lipid content of 4.0% wet weight) accumulated higher hydrocarbon concentrations than cod (muscle lipid content of 0.75% wet weight). Uptake rates of PAHs in clams peaked when gametogenesis was near completion and decreased during spawning, while elimination rates peaked during spawning. Oysters and clams sampled at the high point of lipid and glycogen reserves during their spawning cycles (the fall) had PAH tissue levels that were 2 to 3 times higher than they were when sampled during the spring. High elimination rates during the loss of lipid-rich eggs are consistent with findings that finfish and shellfish tend to accumulate PAHs in tissues with high lipid content because PAHs are strongly hydrophobic.

Potential variations in PAH uptake and elimination rates in seafood species due to seasonal and physiological variation should be taken into account during spill response. These differences should be considered when designing seafood sampling plans and when comparing analytical results from samples from different species, collected at different times of year, or collected during different stages in the life cycle of the organisms.

Chronic Exposure Stress

Bioaccumulation levels and elimination rates of hydrocarbons for finfish and shellfish may depend on the type and duration of exposure to petroleum products, and the extent to which the organisms have been chronically exposed to other contaminants. Chronic exposure appears to reduce elimination capacity. In fact, there may be two phases of elimination: an initial rapid phase followed by a second slower phase for PAHs that are sequestered in stable compartments of the organism, such as storage lipids. Some chronic hydrocarbon pollution studies have indicated no significant reductions in PAH levels in tissues over 2-4 months for clams and mussels, even when the animals were moved to cleaner habitats. The ratio of liver/muscle concentrations in finfish sometimes can be used as an indicator of the level of chronic PAH contamination at a site. Liver levels represent shorter-term exposure to oil, while muscle levels represent longer-term bioaccumulation. Therefore, lower liver/muscle ratios may indicate decreased efficiency in an organism's ability to biotransform absorbed or ingested oil into compounds that are easily excreted.

Other subsistence and recreational seafood organisms

Some organisms that are collected and consumed for subsistence and recreation were not discussed in this section. Examples are octopus, squid, seals, whales, seaweed, and algae. There isn't enough information on these organisms to thoroughly discuss the level of risk they may pose to consumers following an oil spill. It should be noted, however, that if these organisms occur in a spill area and are exposed, restrictions on harvest or consumption advisories might be warranted, depending on contamination and consumption levels.

Summary

- Wild finfish are unlikely to become contaminated or tainted because they typically are either not exposed or are exposed only briefly to the spilled oil and because they rapidly eliminate petroleum compounds taken up. Exceptions may occur if a large amount of fresh, light oil is mixed into the water column or if bottom sediments become contaminated. If nearshore sediments are contaminated, species that spawn in nearshore and shallow waters are more likely to be exposed to spilled oil than pelagic and benthic species.
- Penned finfish are more susceptible to tainting and contamination because they are not able to escape exposure.
- Shellfish are more likely than finfish to become contaminated from spilled oil because they are more vulnerable to exposure and less efficient at metabolizing petroleum compounds once exposed.

- Among crustaceans, species that burrow are at the highest risk of exposure at spills where bottom sediments are contaminated, followed by species that utilize nearshore and estuarine benthic habitats.
- Bivalves are at high risk of contamination because they are sessile, filter- and deposit- feed, and occur in substrates in shallow subtidal and intertidal areas that are more likely to become contaminated.
- It is generally accepted that uptake and elimination rates both increase with temperature, though study results are somewhat contradictory.
- PAHs tend to accumulate to higher concentrations in lipid-rich tissues and organisms. Sea-sonal differences in tissue lipid content associated with spawning may influence uptake and elimination rates of PAHs in some marine species.
- Chronic exposure to hydrocarbons in water and sediments may reduce elimination capacity.

MONITORING SEAFOOD FOR CONTAMINATION

The preceding section described information that can help determine the likelihood that spilled oil will expose and contaminate seafood. If it is decided that seafood is at significant risk, the next step is monitoring to determine whether seafood actually is contaminated, and to characterize the extent and degree of contamination. This section provides general guidelines for developing seafood sampling plans and conducting sensory and chemical testing of seafood samples for petroleum contamination.

Developing Seafood Sampling Plans

The first step in developing a sampling plan is defining the questions to be answered. Sampling should not begin before study objectives have been clearly established. Because every oil spill is a unique combination of conditions and the objectives of seafood sampling may vary from spill to spill, there is no standard sampling plan that can be applied to all seafood contamination monitoring studies. Generally, though, any sampling plan to monitor for potential seafood contamination from an oil spill should specify the study area, sampling locations, target species, number of samples to be collected, timing of initial and repeat sampling, sample collection methods and handling procedures, and analyses to be conducted. The statistical design must ensure sufficient statistical power to provide the information needed at the desired level of confidence to support seafood management decisions.

Some general guidelines for designing a seafood-sampling plan are presented below. For more detailed guidelines, see *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories Volume 1: Fish Sampling and Analysis* by the U.S. Environmental Protection Agency (2000). For more detailed sampling guidelines for sensory testing, see *Guidance on Sensory Testing and Monitoring of Seafood for Presence of Petroleum Taint Following an Oil Spill* (Reilly and York 2001).

Selecting sampling locations

In selecting sampling locations, all likely pathways of oil exposure should be identified (*e.g.*, surface slicks, dispersed or dissolved oil in the water column, submerged oil associated with bottom sediments), so that risks to specific fisheries can be evaluated. Inclusion of commercial, recreational, and subsistence harvest areas should be considered.

Collection of pre-exposure samples from the spill area or samples from appropriate unexposed reference areas is extremely important because they can provide information on background levels of contamination in the spill area. Petroleum hydrocarbons are ubiquitous in environmental samples, so we cannot assume that all petroleum hydrocarbons measured in a sample or all increases over time are a result of an oil spill. Furthermore, monitoring often continues until the level of contamination returns to “background.” Reference samples are key to determining the range of background concentrations and the baseline against which changes over time will be evaluated.

The best reference samples are pre-spill samples taken in areas not yet oiled but in the potential path of the oil (“before” can be compared with “after” exposure). If pre-spill sampling is not possible, unexposed reference sites comparable to exposed sites can be selected for sampling. However, site histories and differences in the characteristics of the sites should be carefully evaluated to determine whether there are significant differences between the exposed and reference areas. Often, areas that escape oiling do so because they differ fundamentally from exposed areas (for example, bays that face different directions), and so would not be expected to exhibit the same “background” conditions. Any differences between reference and exposed sites must be considered when analyzing and interpreting results.

National monitoring programs such as NOAA’s National Mussel Watch Program can provide valuable pre-spill data for determining historical ranges of background concentrations of PAHs in shellfish at several locations around the country. When available for an area, PAH data from the NOAA Status and Trends Program (including the National Mussel Watch Program) or other monitoring programs may help determine normal background levels and seasonal patterns in contaminant levels.

Selecting target species to be sampled

Evaluating risk to human health from seafood consumption usually is a primary purpose of seafood sampling, so including species harvested commercially, recreationally, and for subsistence use may be important. Species that are present throughout the area of concern may be most appropriate for sampling if results are to be compared spatially or if the results are to be used to make statistical inferences to the entire area.

Hydrocarbon uptake and elimination rates vary widely. Finfish, for example, quickly metabolize and eliminate PAHs. Bivalves generally tend to bioaccumulate most contaminants and often serve as good indicators of the potential extent, degree, and persistence of contamination. On the other hand, some shellfish species stop feeding or passing water over their gills at extreme temperatures and, consequently, may exhibit low uptake rates under certain conditions. Consider such differences when selecting species for monitoring and comparing results among species.

Sampling frequency and duration

Monitoring generally should continue until contaminant levels reach background levels or predetermined acceptable levels. Periodic sampling before those levels are reached can reveal trends in contaminant levels. Appropriate monitoring frequency and duration will depend on spill conditions, such as oil type and volume spilled, flushing rates of affected water bodies, and the degree of exposure to wave action of contaminated shorelines. Appropriate monitoring frequency and duration will also depend on the species exposed and exposure duration. Finfish generally eliminate hydrocarbons within days or weeks, whereas bivalves may require several weeks or months. Elevated levels of petroleum compounds in bivalves have been detected for years at some sites where high levels of oil persist in adjacent sediments. Time of year should also be considered in some climates because elimination rates may be slower in cold temperatures. Other factors to consider with regard to monitoring frequency are the turnaround time for sample analysis and time required for the evaluation team to meet, interpret the results, and decide on the need for further sampling. Sampling plans may need to be adjusted over time as conditions change and as monitoring results provide new information on the fate of the oil and on which pathways of exposure are significant.

Sample collection and handling

The seafood-sampling plan should specify all details about sample collection. This includes the areas to be sampled, number of samples to be collected from an area (to meet statistical objectives), number of organisms or quantity of tissue to be composited (to meet analytical requirements), size of organisms to be collected, tidal elevations for collection (in the case of intertidal invertebrates), method of marking or recording exact sampling locations, and field notes to be recorded.

The sampling plan should also specify how seafood samples should be handled. This includes any field preparation, packaging and temperature requirements (for example, wrapping in foil, keeping in a cooler at 4°C

or below, and freezing within a specified period of time), labeling, and any chain-of-custody requirements during transport to the analytical laboratory. The edible portion, which may vary culturally, is usually the portion of interest. Seafood samples collected for sensory testing generally should be handled as they would be during commercial, recreational, or subsistence harvest and transport.

Procedures should be followed to prevent cross-contamination in the field (such as preventing exposure of samples or sampling equipment to exhaust fumes and engine cooling systems on vessels) and to maintain the integrity of the samples. Likewise, good laboratory practices should be employed to prevent contamination of samples during preparation and analysis.

Testing Seafood for Contamination and Tainting

Generally, two different types of evaluations can be conducted after oil spills to determine whether seafood is contaminated. Sensory testing determines whether seafood is tainted, *i.e.*, if it has an off-odor or off-flavor. Chemical analysis determines whether tissues are contaminated with targeted compounds. Detailed methods of chemical analysis can indicate the presence as well as the quantity of specific contaminants in tissues. These results can be used to evaluate risk to human health through consumption of contaminated seafood. Summaries of these types of seafood testing are described below.

Sensory evaluation of seafood for presence of petroleum taint

When an oil spill occurs, local seafood resources may be exposed to petroleum compounds that affect their sensory qualities; that is, smell, taste, and appearance. Even when seafood from a spill area is considered acceptable with regard to food safety, flavor and odor may still be affected, negatively impacting the seafood's palatability, marketability, and economic value. Furthermore, tainted seafood is considered by the U.S. Food and Drug Administration to be adulterated and, therefore, is restricted from trade in interstate commerce.

Tainted seafood is defined as containing abnormal odor or flavor not typical of the seafood itself (ISO 1992). Under this definition, the odor or flavor is introduced into the seafood from external sources and excludes any natural by-products from deterioration due to aging during storage, decomposition of fats, proteins, or other components, or due to microbial contamination normally found in seafood. Taint is detected through sensory evaluation, which has been defined as "the scientific discipline used to evoke, measure, analyze and interpret those reactions to characteristics of foods and materials as perceived through the senses of sight, smell, taste, touch and hearing" (Food Technology Sensory Evaluation Division 1981). Humans have relied for centuries on the complex sensations that result from the interaction of our senses to evaluate quality of food, water, and other materials. In more recent times, sensory testing has developed into a formalized, structured, and codified methodology for characterizing and evaluating food, beverages, cosmetics, perfumes, and other commercial products. Sensory evaluation techniques are routinely used commercially in quality control, product development, and research. Sensory testing can be either subjective or objective. Subjective testing measures feelings and biases toward a product rather than the product's attributes. For objective testing, highly trained assessors use the senses to measure product attributes. Testing of seafood for petroleum taint should be completely objective and should be conducted by highly trained analysts.

Objective sensory testing serves as a practical, reliable, and sensitive method for assessing seafood quality. Only human testers can measure most sensory characteristics of food practically, completely, and meaningfully. Though advances continue to be made in developing instrument-based analysis, human senses remain unmatched in their sensitivity for detecting and evaluating organoleptic characteristics of food. The U.S. Food and Drug Administration and NOAA's National Marine Fisheries Service routinely employ sensory evaluation in inspecting seafood quality. Seafood inspectors are essentially sensory analysts, or assessors, who work as expert evaluators in the application of product standards. A major objective of seafood sensory inspection is to evaluate quality with regard to decomposition of fisheries products. Sensory analysis can also provide information on presence of taint from external sources, such as spilled oil and chemicals.

Sensory panels

Objective sensory evaluation of seafood is usually conducted using a panel of trained and experienced analysts. Sensory analysts must be screened for sensitivity and then trained in applying established sensory science methodology. Participation in calibration or “harmonization” workshops ensures uniform application of sensory evaluation criteria for particular types of contaminants, including standard terminology and consensus on levels of intensity of sensory characteristics. Descriptive analyses and references are used to yield results that are consistently accurate and precise.

There are different types of sensory analysts, which function differently and have specific selection, training, and validation requirements. *Trained assessors* are sensory analysts selected and trained to perform a specific task. *Expert assessors* are the most highly trained and experienced category of sensory analyst. Expert assessors generally evaluate product full-time, function independently, and often are used in quality control and product development. Examples of products evaluated by expert sensory assessors include wine, tea, coffee, and seafood. Through extensive standardized training and experience with sensory methodology, these expert assessors have become extremely objective and evaluate quality with a high degree of accuracy and precision. Seafood inspectors fall into the category of expert assessors, and can make consistent and repeatable sensory assessments of quality characteristics of seafood as they relate to grade level or decisions to accept or reject product.

The number of panelists needed depends on the level of expertise and experience of the analysts used. For panels of expert assessors, such as NMFS and FDA seafood inspectors, usually only three to five analysts are needed. If less experienced analysts are used, a larger number of panelists is recommended. Whenever possible, use of expert seafood assessors, such as seafood inspectors, is recommended for evaluation of seafood for presence of petroleum taint. Extensive product knowledge and experience enable seafood inspectors to very accurately distinguish variations related to product processing, storage, deterioration, etc. from taint due to external sources. Some seafood inspectors for NMFS and FDA have had specialized training for detecting petroleum taint in seafood and experience evaluating seafood samples at oil spills. If called upon, these specialized inspectors are available to conduct sensory evaluation of seafood during spill events.

Sensory evaluation procedures

Applied as a science, sensory evaluation should be conducted under specific, highly controlled conditions in order to prevent extraneous influences in the testing environment from affecting panelists’ sensory responses. Accordingly, sensory testing is best conducted in facilities specifically designed for sensory testing. The NMFS Seafood Inspection Branch maintains several such laboratories around the country. Seafood samples collected during a spill event can be shipped to these laboratories for sensory evaluation. In most cases, NMFS and FDA recommend that samples be shipped and evaluated in the same manner as they normally are shipped and sold (*i.e.*, fresh, live, frozen). When this is not possible, as may be the case for oil spills in very remote areas, sensory analysts can conduct evaluations at the scene of an incident.

All sensory testing should be conducted under the supervision of a sensory professional, who designs and implements the sensory testing procedure. A trained “facilitator” should coordinate sensory analysis. The facilitator conducts the testing, including receiving, preparing, and presenting samples to the expert sensory panel, and collecting the resulting data in a scientific and unbiased manner. All of these steps should be conducted according to standardized procedures under highly controlled conditions. Suspect samples are presented to assessors in blind tests, along with control or reference samples. Samples are first smelled raw, then smelled cooked, and finally tasted by each panelist independently to determine whether petroleum taint is present. A sensory professional statistically analyzes panelist’s responses to determine whether samples pass or fail with regard to presence of petroleum taint. These results, in turn, help seafood managers determine whether restrictions are needed on seafood harvest or marketing from the spill area due to tainting.

We are not certain which compounds in petroleum are responsible for taint perceived by humans, so chemical analysis cannot yet substitute for sensory testing in determining whether a taint is present. It has been suggested

that the principal components of crude and refined oils responsible for tainting include the phenols, dibenzothiophenes, naphthenic acids, mercaptans, tetradecanes, and methylated naphthalenes. The human olfactory system generally is very sensitive to phenolic and sulfur compounds, even though they are minor components of oil.

In 2001, NOAA published a technical guidance document on appropriate sensory methodology to objectively assess seafood for the presence of petroleum taint. Written by sensory scientists with NOAA's National Marine Fisheries Service Seafood Inspection Program and Canada's Food Inspection Agency, in cooperation with the U.S. Food and Drug Administration, *Guidance on Testing and Monitoring of Seafood for Presence of Petroleum Taint Following an Oil Spill* comprehensively describes recommended standard procedures, including collection, preservation, and transport of seafood samples, for sensory evaluation. The guidance is intended to assist in conducting scientifically sound and legally defensible sensory tests on seafood during oil spill response, with adequate and appropriate quality control.

Chemical testing techniques for petroleum contaminants in seafood

Chemical testing of seafood often is conducted after an oil spill to determine whether seafood tissues are contaminated with petroleum compounds. Both detailed and screening methods of analysis can be employed. Below, we summarize methods typically used after past oil spills, including some of their advantages and disadvantages.

DETAILED METHODS OF CHEMICAL ANALYSIS: GAS CHROMATOGRAPHY/MASS SPECTROMETRY

Detailed chemical analysis of seafood after oil spills typically is conducted using gas chromatography and mass spectrometry (GC/MS), which measures individual PAHs at very low detection levels and provides a PAH pattern (or fingerprint) to compare to that of the source oil. Prior to analysis, hydrocarbons are extracted from seafood tissue samples and the extract is split into three fractions: 1) the saturated hydrocarbons fraction (containing the n-alkanes, isoprenoids, steranes and triterpanes; 2) the aromatic hydrocarbon fraction (containing the PAHs and sulfur heterocyclics; and 3) the polar hydrocarbon fraction (containing the nitrogen heterocyclic compounds. Recovery standards appropriate to each fraction are added.

The PAHs in the fraction generally are of greatest concern with regard to risk to human health. The gas chromatograph separates targeted PAH compounds yielding a retention time that, in combination with the mass spectra from the mass spectrometer, enable detailed identification of individual compounds by their ion masses. The method often used is usually referred to as "Modified" EPA Method 8270, which is EPA Method 8270 for semi-volatile compounds modified to include quantification of the alkyl-substituted PAH homologues, in addition to the standard PAH "priority pollutants." In oil, alkylated homologues of PAHs are more predominant than parent PAH compounds, often by an order of magnitude. This is in contrast to pyrogenic (combustion) and other potential PAH sources. The detailed chemical fingerprint provided by GC/MS analysis enables differentiation among sources of PAHs found in the sample. Contamination from a specific spill can be distinguished from background sources of contamination, such as PAHs derived from combustion sources. GC/MS can also measure analytes other than PAHs to help with fingerprint analysis of oil or to track oil weathering. The GC/MS can be run in the selected ion monitoring (SIM) mode, rather than the full-scan mode, to increase the minimum detection levels (MDL) of the individual parent and selected homologue PAHs by a factor of 10 to 40. Minimum detection levels for individual PAHs are very low, in the range of parts per billion (ng/g) in tissue. The quantitative results for specific, targeted PAHs can be used to assess whether levels detected pose a risk to human health through seafood consumption.

Normal turnaround time for analysis of tissue samples for PAHs is approximately two weeks. Fast turnaround time is approximately three days for a batch of samples. Costs for GC/MS-SIM analysis of tissues are relatively high, starting from about \$750 per sample, plus premiums of 50-100% for fast turnaround. The sample-processing rate depends on the throughput capabilities of the laboratory and the degree of quality control (QC) of the data before the results are released, ranging from approximately 20 to a maximum of 100 samples per week.

Data Reporting and Interpretation

The importance of data reporting and interpretation should not be underestimated in planning seafood safety monitoring programs after oil spills. Some simple steps can be taken to help avoid confusion and prevent incorrect conclusions. For example, the analytical laboratory should include at least the following information for all analytical data reported:

Header Information

- *Sample Name or Field ID: the sample name or number assigned by the sampler*
- *Sample Type: e.g., sample, field blank, trip blank, procedural blank, QC*
- *Batch No.: analytical batch number (so samples run as a batch can be identified, particularly if problems are found with a batch run)*
- *Matrix: e.g., water, sediment, tissue, oil*
- *Percent Moisture: for tissue and sediment samples*
- *Sample Size: weight or volume of sample used for analysis*
- *Collection Date: date the sample was collected*
- *Extraction Date: date the sample was extracted*
- *Analysis Date: date the sample was analyzed*
- *Analysis Method: EPA Method or other description*
- *Surrogate Corrected?: Are the reported concentrations corrected for surrogate recovery?*
- *Method Detection Limit: the minimum detection level*
- *Units: units in which the concentration is reported, including whether concentrations are wet weight or dry weight (for tissue)*

Analyte Data

- *Individual and Total PAH concentrations*
- *Surrogate Recovery (%): for every sample*
- *Key to Data Qualifiers: The lab should include a key to any qualifiers used to flag reported values that have some kind of data accuracy issue. For example, two standard qualifiers used under the USEPA Contract Laboratory Program guidelines (USEPA 1994) are:*
- *U = the analyte was analyzed for, but was not detected above the reported sample quantification limit*
- *J = the analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample*

Analysis of the source oil, if available, is needed to enable fingerprint comparisons. Only expert petroleum hydrocarbon chemists should interpret fingerprints because the complex processes of oil weathering and uptake result in variable PAH patterns in organisms. Also, patterns can be difficult to interpret in samples collected from areas with high background levels of contamination.

Caution is advised when comparing analytical results for samples of different types, or samples collected from different areas or at different times. Before drawing conclusions, consider any differences in the analyses conducted or the way the data are reported. Examples of differences to watch for include:

- The units in which results are reported, and whether reported concentrations are dry or wet weight;
- Whether the lists of analytes and minimum detection limits for individual PAHs are the same;
- Whether reported concentrations have been corrected for surrogate recovery; and

- Whether reported concentrations have been lipid-normalized. PAH uptake and retention tend to increase with the increasing lipid content of tissues. Consequently, differences in lipid content may need to be considered when comparing and interpreting analytical results over time or among different organisms.

Rapid screening methods of analysis

Rapid, low-cost analytical methods, generally known as screening methods, can be employed to identify contaminated samples and prioritize them for detailed analysis. Detailed methods of analysis for PAHs in tissue are time-consuming and expensive. The large number of samples often collected after an oil spill can quickly overwhelm laboratory capacity and strain resources. Screening methods of analysis can rapidly process large numbers of samples to yield semi-quantitative estimates of contaminant concentrations and allow ranking of samples by degree of contamination. Used in a tiered approach, screening methods can identify the most contaminated samples, prioritizing or reducing the number of samples that need to be processed by detailed analytical techniques, such as GC/MS.

For example, in response to the need to analyze large numbers of subsistence seafood samples collected after the *Exxon Valdez* oil spill in Prince William Sound, Alaska, NOAA's Northwest Fisheries Science Center used reverse-phase, high performance liquid chromatography (HPLC) with fluorescence detection to screen for metabolites of aromatic compounds in finfish bile. Finfish rapidly metabolize aromatic compounds and concentrate the resulting metabolites in bile for excretion, often at concentrations that are orders of magnitude greater than those in edible tissue. Using this rapid, low-cost method, hundreds of finfish tissue samples were screened for indication of exposure to petroleum contaminants, enabling GC/MS analyses to be focused on selected samples to confirm presence and quantities of individual contaminants. HPLC/UV fluorescence screening methods have also been used for rapidly measuring aromatic compounds in invertebrate tissues. This screening method was used successfully on lobster samples collected after the *North Cape* oil spill off the coast of Rhode Island in 1996.

Screening analyses, such as the HPLC/fluorescence method described above, generally can be completed in rapid turnaround time (within 24 hours) and can be conducted on a research vessel or onshore lab. Rapid availability of results enables sampling modifications based on indications of exposure. This can be very helpful during the critical early phases of an oil spill response, when decisions regarding closing or otherwise restricting seafood harvest may be made.

The utility of HPLC/fluorescence and other screening methods, however, is more limited than detailed methods of analysis. For example, though it may be possible to recognize chromatographic patterns associated with characteristic classes of petroleum products, HPLC/fluorescence screening does not produce a detailed "fingerprint" similar to the results acquired from GC/MS. Consequently, HPLC/fluorescence usually will not enable differentiation between background contamination sources and the spilled oil, especially in very polluted areas. Since HPLC/fluorescence screening does not quantify individual aromatic compounds, the results cannot be used to assess risk to human health from consumption of contaminated seafood. Furthermore, measurement of fluorescent aromatic compounds in bile is not a standard analysis, limiting temporal and spatial comparisons using historical data sets. Lastly, HPLC/fluorescence screening for fluorescent aromatic compounds in bile is a specialized technique, and laboratory availability and expertise needed to conduct the analyses reliably may be limited.

Water Monitoring

Water samples often are collected and analyzed as part of the initial spill response and assessment. Seafood safety managers can use these results to help estimate the extent and duration of seafood exposure to oil in the water column. Monitoring water concentrations may also be important if water-quality criteria are applied as a condition for reopening a closed fishery or removing other harvest restrictions.

Oil concentrations in the water column generally peak early after an oil spill and, in most cases, rapidly decline

to background levels within days to a week, as was the case for example at the *New Carissa* oil spill. Accordingly, if water sampling is to be conducted, initial sampling should commence very soon after a spill occurs. Oil may persist longer than usual in the water column if there are multiple or ongoing oil releases, if the released volume is extraordinarily large, or if large volumes of oil are physically dispersed. After the *Braer* oil spill, for example, elevated oil concentrations were detected in the water column as long as 50 days after release. Dissolved and dispersed oil plumes in the water column are driven by currents and so may have a very different spatial distribution than surface slicks, which are driven primarily by wind.

Under the authority of the Clean Water Act (63 FR 68354-68364), EPA has issued national recommended water-quality criteria for priority toxic pollutants to be used by states and tribes in adopting water quality standards. EPA has issued water-quality criteria for protection against human health effects for three mono-aromatic hydrocarbons and eight PAHs (listed in Table G.2-3). These particular compounds, however, are present in crude oils and refined products at very low levels and constitute a tiny percentage of the PAHs normally detected in water samples after an oil spill. None of the water quality criteria to protect aquatic communities (both freshwater and saltwater) issued by EPA are for PAHs. EPA has issued recommended water quality criteria for organoleptic effects for 23 chemicals, though not for any of the compounds present in petroleum products. Some states have established state water quality standards for PAHs in their coastal waters.

Sediment Monitoring

Sediment monitoring can be included as part of a post-spill monitoring program to determine whether sediments may be a potential chronic source of oil exposure to adjacent seafood collection sites, particularly at intertidal sites where bivalves are harvested. Sediment sampling also may facilitate fingerprint analysis of PAHs in tissues by providing the PAH pattern in contaminated sediments, which may be different than the PAH pattern in the fresh source oil. It is important to recognize, however, that sediments often contain high levels of background PAH contamination, particularly in urban areas and harbors. PAHs and other contaminants detected may not be

related to a particular oil spill. Also, characterization of sediment contamination can be difficult because of the inherent heterogeneity of intertidal sediments over space, depth, and time.

There are no national sediment quality criteria for PAHs in marine or freshwater sediments. Some states have established sediment quality standards and cleanup screening levels to prevent adverse biological effects. How these standards would relate to seafood adulteration or safety issues is unclear.

Table G.2-3 National recommended water quality criteria for priority toxic pollutants for protection against human health effects.

PAH priority pollutant	Human health criteria for consumption of water + organism (µg/L)	Human health criteria for consumption of organism only (µg/L)
Benzo[a]anthracene	0.0044	0.049
Benzo[a]pyrene	0.0044	0.049
Benzo[a]fluoranthene	0.0044	0.049
Benzo[k]fluoranthene	0.0044	0.049
Dibenzo[a]anthracene	0.0044	0.049
Fluoranthene	300	370
Fluorene	1300	14000

SEAFOOD RISK ASSESSMENT

(Risk assessment and determination of cancer risk should be conducted by the California Department of Public Health).

Several different endpoints can be considered when assessing risks posed to human health from consuming contaminated seafood. These include both carcinogenic and non-carcinogenic effects to the general population, as well as to particularly susceptible segments of the population such as children, pregnant women, and subsistence seafood consumers. Human epidemiological studies, when available, and laboratory studies involving animals are used to assess the likely effects of contaminants at various exposure levels.

Evidence from occupational studies of workers exposed to mixtures of PAHs indicates that many of these compounds may be carcinogenic to humans. Individual PAHs that are considered to be probable human carcinogens include benz[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, chrysene, dibenz[a,h]anthracene, and indeno[1,2,3-cd]pyrene (IRIS 1994). Most of the data gathered from laboratory studies provides information on carcinogenic effects of lifetime exposure to PAHs. Information on non-carcinogenic effects is limited. Consequently, cancer generally is the primary endpoint considered when assessing potential risks to human health from consumption of seafood from an oil spill area.

Seafood Advisory and Action Levels from Previous U.S. Oil Spills

The action or advisory levels resulting from cancer risk calculations differ among spills, depending on the assumptions made and input values selected. At the *New Carissa* oil spill, the Oregon Health Division calculated action levels for average and upper end shellfish consumers of 45 ppb BaP equivalents (BaPE) and 10 ppb BaPE, respectively. Action levels derived by the California Department of Health Services for average and upper-end shellfish consumers following the *Kure* spill were 34 ppb BaPE and 5 ppb BaPE, respectively. At the *North Cape* oil spill, the Rhode Island Department of Health essentially applied a BaPE criterion of 20 ppb for the maximally exposed lobster consumer over the five-year exposure duration. Action levels calculated by the Maine Bureau of Health for lobster consumption after the *Julie N* oil spill for ten and 30- year exposure durations were 50 ppb and 16 ppb BaPE, respectively. Advisory levels for subsistence consumers after the *Exxon Valdez* oil spill, assuming a ten-year exposure period, were three ppb BaPE for salmon, five ppb BaPE for finfish, 11 ppb BaPE for crustaceans, and 120 ppb BaPE for bivalve mollusks. Advisory levels based on a lifetime exposure assumption were approximately an order of magnitude lower. None of the finfish or shellfish samples collected from harvesting areas near Prince William Sound exceeded these advisory levels. Interestingly, the upper-bound lifetime cancer risk for Alaskan subsistence seafood consumers eating the most contaminated bivalve mollusks from the spill area was calculated to be two orders of magnitude lower than the lifetime risk calculated for consumers of locally smoked salmon

At several of these spills, the calculated action levels were used as recommended levels for reopening harvest of closed seafood fisheries. For example, at the *New Carissa* oil spill, shellfish were considered safe if all samples contained less than 10 ppb BaP equivalents. If any shellfish tissue levels were above 45 ppb BaP equivalents, shellfish in those areas would be considered unsafe, and further monitoring considered necessary. If samples contained more than 10 ppb but less than 45 ppb BaP equivalents, the need for further monitoring would be assessed on a case-by-case basis. A similar tiered approach was used at the *Kure* oil spill. If all samples contained less than 5 ppb BaP equivalents, shellfish beds could be reopened. If any samples contained between 5 and 34 ppb BaP equivalents, the need for further action before reopening would be assessed. If any samples contained more than 34 ppb BaP equivalents, additional sampling and environmental monitoring prior to reopening would be considered.

The Equivalency Approach for Risk Assessment

The equivalency approach used in relative cancer risk assessment is a method used for assessing the risk of

exposure to a mixture of several different compounds that are related in terms of chemical and biological activity. Rather than calculating individual risks for each compound, one component of known potency is used as a standard. Concentrations of each of the other compounds are adjusted based on their estimated potency relative to the standard, to calculate an equivalent concentration for the standard. Summing the equivalent concentrations yields a single number from which the cancer risk can be estimated.

This toxicity equivalency approach has been widely used for mixtures of dioxins and furans, for example. The relative potencies of individual dioxin and furan compounds are expressed in terms of 2,3,7,8-tetra-chlorodibenzo-*p*-dioxin (2,3,7,8-TCDD) equivalents. 2,3,7,8-TCDD was chosen as the standard by which the potency of individual dioxin and furan compounds are estimated because most laboratory studies on the effects of dioxins have been conducted using 2,3,7,8-TCDD. Data are more limited on the effects of other congeners. The same approach can be used with petroleum compounds, which also occur in complex mixtures.

SEAFOOD TAINT RISK COMMUNICATION

Both technical and social factors should be considered when communicating information on the health and safety of seafood following an oil spill, particularly when dealing with different groups. The risks and consequences have different meanings for the subsistence user, sport fisher, average consumer, commercial fisher, elected official, regulator, and responsible party representative. Regulators and scientists measure risk quantitatively and accept the uncertainty inherent in the risk-assessment process. The public perceives risk more qualitatively and subjectively, and is influenced by prior experience with similar risks and information made available to them. The public wants to know whether the seafood is safe to eat; yet the answers given are typically posed in terms of “acceptable risk” or “not a significant risk.” Risk communicators should be aware of and try to overcome: 1) gaps in knowledge, 2) obstacles inherent in the uncertainties of scientific risk assessment, and 3) barriers to effective risk communication.

Please see [Appendix F](#) for further general information on risk communication approaches and techniques. In addition:

- Meet directly with groups such as commercial fishing associations, recreational users, subsistence users, seafood vendors, etc. Meetings can fail if the risk communicators are not prepared or knowledgeable, or appear to be withholding information. Specialized bulletins or communication methods may be necessary for special groups, such as Native American subsistence users and non-English-speaking users.
- Use unambiguous terms whenever possible. Health risks are commonly described in terms of probabilities of cancer based on assumed consumption rates and periods. It is assumed that carcinogens do not have safe thresholds for exposures; that is, any exposure to a carcinogen may pose some cancer risk (USEPA 2000b). However, it is both useful and appropriate to define “safe” and “unsafe” levels of PAHs in seafood based on risk rates that are commonly considered to be acceptable. For example, water-quality criteria for carcinogenic contaminants in water usually use risk rates in the range of 10^{-5} to 10^{-6} . The general public understands the concepts of acceptable risks, although there may be components of society where these risks conflict with local cultures, such as the Alaska Native subsistence users during the *Exxon Valdez* oil spill. As long as the risk communicators clearly define what is meant by “safe” and “unsafe,” these terms are appropriate.

Communicating Relative Risks

Risk communicators commonly compare the relative risk of a specific activity to known risks of other activities. For example, the public is accustomed to hearing the risks of death by automobile accident or airplane crash. These are considered voluntary risks taken by people who decide to drive or fly after considering the risks and benefits associated with these activities, whether or not their perceptions are realistic. The public generally will accept risks from voluntary activities that are roughly 1,000 times greater than involuntary risks that provide the same level of benefits.

Because the potential human-health risks from eating seafood contaminated by an oil spill are associated with PAHs, it is tempting to compare the PAH levels in seafood samples with those found in other food sources. PAHs are ubiquitous contaminants, measurable in many foods. Based on information from previous spills, PAH levels in seafood from oil-spill-contaminated waters generally are considerably lower than PAH levels found in smoked foods. During the *Exxon Valdez* oil spill, however, village community residents became upset when it was pointed out that samples of smoked fish from the villages contained carcinogenic hydrocarbon levels hundreds of times higher than any shellfish samples collected from oiled beaches, and nearly 10,000 times higher than wild salmon. The residents considered eating smoked salmon to be an acceptable, voluntary risk, and eating oil-contaminated seafood to be an involuntary, unacceptable risk. Guidelines for risk communication include being sensitive to the distinction between voluntary and involuntary risk, and avoiding risk comparisons that equate the two. Risk comparisons should be made carefully.

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APPENDIX H

NATIONAL CONTINGENCY PLAN (NCP) PRODUCT LIST

and

STATE LICENSED OIL SPILL CLEANUP AGENTS (OSCA)

Within the U.S. only dispersants that have met the approval criteria set by the U.S. Environmental Protection Agency (EPA) and that are listed on the EPA National Contingency Plan (NCP) Product Schedule can be legally sprayed. The NCP Product Schedule includes the products shown in the table below.

In addition to meeting the approval criteria set by the EPA, dispersants used in California must be a California state-licensed Oil Spill Cleanup Agent (OSCA). The two dispersants currently meeting the state-licensing requirements are also shown below.

Dispersants with federal approval	Dispersants licensed in California
BIODDISPERS	
DISPERSIT SPC 1000	
FINASOL OSR 52	
JD-109	
JD-2000	
NEOS AB 3000	
MARE CLEAN 200	
SAF-RON GOLD	
SEA BRAT #4	
ZI-400	
COREXIT 9527A	COREXIT 9527A
COREXIT 9500A	COREXIT 9500A
NOKOMIS 3-AA	NOKOMIS 3-AA
NOKOMIS 3-F4	NOKOMIS 3-F4

Updated NCP Product Lists can be accessed via the EPA representative on the RRT (Appendix A), by calling the Emergency Response Division of the U.S. EPA (202-260-2342) or accessing the Internet at <http://www.epa.gov/oilspill/ncp/dsprsnts.htm>

Additional information on California state-licensed dispersants may be obtained by contacting the OSPR representative on the RRT (Appendix A) or accessing the Internet at http://www.dfg.ca.gov/ospr/reg_com/osca.html

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APPENDIX I

DETERMINATION PROCESS FOR CALIFORNIA OFFSHORE DISPERSANT ZONES

The use of dispersants in marine waters off California requires detailed foresight and planning. In an effort to expedite a decision to use dispersants and reduce first strike response time, the Regional Response Team Region IX in August of 2000 adopted formal changes to the planning and operations sections of the Regional Contingency Plan (RCP). These sections detail a dispersant use planning process to be undertaken by each of the six California marine Area Committees (AC). Specifically, each AC was tasked with designation of approval zones for dispersant use within its area of operation and the development of a dispersant use plan to include at least the following: 1) Incident Command System (ICS) protocols and forms, 2) Federal On-Scene Coordinator Checklist, 3) dispersant monitoring plan, and 4) wildlife spotting protocols. Finally, each committee was asked to review training and drill requirements for plan implementation as well as dispersant response equipment assuming a 4-hour response time.

Beginning in February 2001, each Area Committee (North Coast, San Francisco-Bay Delta, Central Coast, Los Angeles-North, Los Angeles-South, San Diego) designated a dispersant subcommittee to develop their regional dispersant use zone recommendations. Los Angeles subsequently combined LA-north and LA-south efforts under one subcommittee. San Diego developed an additional Sea Bird Task Force that compiled sea bird information primarily for the Southern California Bight area, and reported their results to the San Diego dispersant subcommittee for their particular consideration in developing recommended zones. All subcommittees initiated the planning process by gathering the pertinent resource data for the region and becoming familiar with the effects of dispersants and dispersed oil in the marine environment. Based on the information reviewed, each subcommittee developed a Net Environmental Benefit Analysis (NEBA) to aid them in constructing the area's dispersant use zone recommendations. Based on the results of the NEBA, each subcommittee ultimately concluded that in the case of dispersible crude and fuel oils, dispersing the spilled oil into the water column may, on balance, be less harmful to the environment than letting the oil remain on the ocean's surface for extended periods of time.

Each subcommittee and Area Committee drafted their dispersant zone recommendations, along with some general dispersant application guidelines, and forwarded those through the U.S. Coast Guard to the RRT. All zone recommendations were approved by the RRT between February 2002 and July 2003. Parallel to the RRT dispersant zone review and approval process, the Los Angeles subcommittee was continuing to meet in workgroups to develop drafts of the other elements (updated FOSC checklist, Wildlife Observation Protocols, Public Outreach Plan, dispersant shortfall analysis, and incorporation of dispersant effectiveness monitoring) necessary to make a complete Area Dispersant Plan (ADP). In doing so, there was a recognition that much of the Los Angeles effort would not only be useful as a starting point for similar efforts by other Area Committees in developing their individual ADPs, but would in fact mature into an overarching California Dispersant Plan that would serve all six marine Area Committee regions in the state and save them the need to develop five other, largely redundant, dispersant plans. This California Dispersant Plan (CDP) includes the zones for each area, as well as an updated Federal On-Scene Coordinator (FOSC) checklist and all appendices needed to implement the CDP.

The Net Environmental Benefit Analysis (NEBA) Process

Once oil is spilled to the ocean there will be inevitable impacts to the environment within the geographical area of the spill no matter how much effort is put into spill response. The primary goal of any oil spill

response is to minimize the area of impact and remove the spilled oil from the water's surface as fast as possible, thus minimizing the impact to the organisms inhabiting the terrestrial, estuarine, intertidal, shallow subtidal and ocean surface environments. This response goal is not meant to overlook the potential for impacts to the organisms found immediately below the ocean surface, but instead provides a mechanism for discussion of the environmental trade-offs associated with any response option.

Each regional dispersant subcommittee assessed and compared the impacts of an oil spill and associated cleanup activities on the biological resources of their area. This examination was conducted using a Net Environmental Benefit Analysis (NEBA), modeled on an Ecological Risk Assessment previously conducted for the San Francisco Bay. In each case, the NEBA examined and compared the risk to the environment associated with available oil spill response options. Spill response options evaluated were 1) no on-water response, 2) mechanical cleanup, 3) *in situ* burning, and 4) dispersant use. The risks of these cleanup options were examined using a NEBA risk matrix, which qualitatively combined the risk to the biological resource resulting from both the magnitude (percentage) of the population impacted with the expected time for the population to recover from the impact.

The NEBA in each area was conducted using an assumed spill of Alaska North Slope crude oil, a dispersible crude oil commonly transported along the coast of California. The approach was a "what-if" analysis in that all sensitive species that could be found in a region, regardless of time of year, were incorporated. This approach was undertaken to eliminate the need to conduct the multiple NEBAs necessary to address spatial and temporal differences found each region. By using this approach, each dispersant subcommittee had all the pertinent resource information at their disposal at one time and could examine and incorporate temporal and spatial differences in their single analysis.

Each regional NEBA had the same general findings:

- 1) In average or worse-than-average offshore response settings, and/or where spill distance from shore significantly increases the response time, mechanical cleanup techniques and *in situ* burning may, by themselves, provide very little improvement over the no response option. When this is the case, these response techniques will not significantly reduce the risk of spilled oil contacting biological resources at the sea surface or in more inshore (*e.g.*, intertidal) regions.
- 2) When used in an appropriate and timely manner, dispersants can remove a significant amount of oil from the surface water. Appropriate and timely application includes a number of decision factors, included in this CDP.
- 3) While dispersants may measurably reduce the risk of oil to surface and coastal biological resources, there may be a temporally limited increase in risk to the plankton community in the upper several meters of the water column.
- 4) Shoreline cleanup methods may not be available or appropriate for use in some sensitive coastal habitats (*e.g.*, rocky intertidal, marshes, wetlands); their inappropriate use may pose a greater risk to these sensitive habitats and dependent species than the oil itself. The goal in this case shifts to keeping the oil from ever reaching sensitive coastal and inland areas.

In the NEBA process, the benefits and risks of each cleanup option were evaluated separately. However, an effective spill response may use a combination of several available response options. Oceanographic conditions permitting, it is expected that dispersants would be used in combination with mechanical cleanup equipment and response strategies.

NEBA results suggested that the appropriate and timely use of dispersants (on oil spills characterized as “dispersible”) could greatly enhance the ability to remove significant quantities of oil from the offshore water surface. This may greatly reduce the risk of spilled oil reaching the more abundant and sensitive habitats and species found in the more inshore, coastal areas. While dispersing oil into the water column can pose a short-term risk to the plankton community inhabiting the upper few meters of the water column, the impacts will be to a much more geographically limited area, and the temporal duration will be relatively very short. The environmental “trade-off” decision-making at the time of a response – weighing the impacts associated with oil on the surface for weeks to months versus the short term toxicity (minutes to hours) resulting from dispersed oil in the water column – can and will be made by the response agencies on a case-by-case spill response basis.

The detailed NEBA matrices developed by each regional dispersant subcommittee are not part of this report, although information about particular resources of concern is summarized in [Appendix B](#).

Environmental “Trade-off” Decisions

The proposed area dispersant zone recommendations acknowledge that weighing of environmental “trade-offs” is not as easy as it may seem, even when information on sensitive resources has been gathered ahead of time. Information on species occurrences and distributions is still very incomplete, as is our knowledge of how they may be affected by prevailing oceanographic conditions.

No resource can be categorized as always being of greater or lesser value than another. For instance, while spill impacts on seabirds, mammals and sensitive communities are more “apparent” to scientists, responders and the general public, other more “hidden” resources (such as the seasonal plankton community in the upper water column) are at potentially greater risk from oil dispersed into the water. This community may contain the larvae of important sport, commercial, and/or ecologically significant (*i.e.*, primary or important animal prey) species.

The following were understandings regarding the plankton communities at risk from a dispersed oil plume:

- In most imaginable response settings, it may be better to disperse the oil into the water column (where there may be short-term toxicity to larvae in the upper few meters of the water column) than to leave the undispersed and unrecoverable oil on the water surface (where it could reside long-term, spread, and potentially impact a wider range of sensitive coastal species and habitats).
- Due to the spatial and temporal distribution of larval species, the dispersed oil from any one oil spill response was expected to impact a very limited portion of the overall community. Many constituent plankton species would quickly replenish their numbers through reproduction or immigration from surrounding waters. It was therefore considered unlikely that there would be population-level affects to the plankton community.
- The concentration of dispersed oil in the open ocean can decrease rapidly through natural dispersion and biodegradation processes. The dispersed oil plume can spread and thin quickly in the three-dimensional space of the water column, and natural biodegradation processes work quickly to break the small droplets of oil in the plume into carbon dioxide and water. In areas where the dilution potential is the greatest (*i.e.*, open ocean), concentrations of dispersed oil high enough to cause adverse effects are unlikely to persist for more than several hours. Oil concentrations are typically less than 50 part per million (ppm) below dispersed slicks, although different authors report slightly

different upper levels. Field data indicate that concentrations of dispersed oil are usually less than 1 ppm at depths below 10 meters. Within a matter of weeks to months, dispersion and biodegradation processes can remove much of the plume of oil droplets from the upper water column, and/or reduce concentrations of oil in the water column and at depth to scientifically non-detectable levels.

- In contrast, undispersed and unrecovered oil left on the water's surface in the open ocean can drift for weeks to months, where it can continue to impact pelagic birds, mammals and perhaps sea turtles. If the oil moves toward shore, it can strand in sensitive coastal habitats (especially intertidal areas) and pose a persistent threat, on a time scale of months to years, to those sensitive coastal habitats and their dependent species and communities.
- Emulsification of the oil remaining at the water surface increases the oil-in-water volume, and hence the contamination risk to marine and coastal plant and animal communities.

Oil spill impacts to marine birds and mammals can threaten the existence and persistence of whole colonies and perhaps the entire population of some species. This is especially true for colonies and populations of common murres, the endangered marbled murrelet, shorebirds (including the endangered western snowy plover) and the southern sea otter.

Stakeholder involvement and outreach efforts

The regional Area Committees, which developed the pre-approval dispersant zone recommendations, and from those this document, are mandated by the Oil Pollution Act of 1990 to include any interested member of the public. Given the sensitivity that dispersant use issues can raise, each regional Area Committee made special and repeated efforts to bring interested stakeholders onto the dispersant subcommittees even if they had not shown previous or consistent interest in other Area Committee response planning work. Generally, in spite of these efforts, most dispersant subcommittees came to include those who were already the most active in their respective Area Committees. Statewide information-sharing and continuity was provided by the Office of Spill Prevention and Response (OSPR), California Coastal Commission (CCC) and the National Oceanic and Atmospheric Administration (NOAA).

In early 2001, a team of RRT representatives made a presentation at a public meeting of the California Coastal Commission; another presentation of the same material was later made at the Gulf of the Farallons Research Symposium. Throughout 2001 and 2002, there were several "Stakeholder Meetings" to distribute the dispersant response planning information to other agencies and interested members of the public. The OSPR and NOAA staff also provided the materials for the U.S. Fish and Wildlife Service and National Marine Fisheries Service reviews, and regularly briefed the RRT on progress of each dispersant subcommittee. OSPR and CCC staff regularly briefed the state Oil Spill Technical Advisory Committee.

Further public outreach was offered in public information sessions at several coastal locations in California and at a public meeting of the California Coastal Commission. The U.S. Coast Guard will also publish a Federal Register Notice of this plan once it is finalized, on which the public may comment.

APPENDIX J

RESULTS OF REVIEWS WITH OTHER AGENCIES

J.1 U.S. Fish and Wildlife Service (Endangered Species Act)

Underway. Insert when **completed**

J.2 National Marine Fisheries Service (Endangered Species Act, Marine Mammal Protection Act, Essential Fish Habitat)

- Regional Response Team Request
- Department of Commerce Review

J.3 California Coastal Commission (Coastal Zone Management Act)

Occurs at end of process. Insert when completed.

J.2 National Marine Fisheries Service (Endangered Species Act, Marine Mammal Protection Act, Essential Fish Habitat

Regional Response Team IX

National Oil and Hazardous Substances Contingency Plan

November 17, 2005

Environmental
Protection Agency

United States
Coast Guard

Agency for Toxic
Substances and
Disease Registry

Department of
Agriculture

Department of
Commerce

Department of
Defense

Department of
Energy

Department of
Health and Human
Services

Department of
Interior

Department of
Justice

Department of
Labor

Department of State

Department of
Transportation

Federal Emergency
Management
Agency

General Services
Administration

Region 9 Tribes

State of Arizona

State of California

State of Nevada

Mr. Ray Bosch
U.S. Fish and Wildlife Service
Endangered Species Act Section 7
1655 Heindon Rd.
Arcata, CA 95521

Dear Mr. Bosch:

Subject: Request for Formal Consultation under ESA Section 7

In accordance with the requirements of Section 7 of the Endangered Species Act, we are requesting the initiation of Formal Consultation on the effects of the Regional Response Team IX implementation of the Pre-Approval Process of its Dispersant Use Plan. Through informal consultation with you, we have determined that proposed application of chemical dispersants under the Dispersant Use Pre-Approval Process may affect, and is likely to adversely affect, some listed species (see enclosed Biological Assessment). The Regional Response Team has also determined that the proposed use of chemical dispersants under the Pre-Approval Process may affect, but is not likely to adversely affect, several other listed species.

Please note that the Dispersant Use Plan, and the Dispersant Pre-Approval Process, has been developed with the assistance of representatives of the U.S. Fish and Wildlife Service as members of one or more of the six Coastal Zone Area Committees, and in accordance with the procedures identified at 40 CFR Part 300, the National Contingency Plan. While these actions may result in short-term adverse effects, it is our belief that the listed species will ultimately benefit from them.

To assist in completing Formal Consultation, please find attached the Biological Assessment that has been produced through the planning process described in the Inter-agency Memorandum of Agreement Regarding Oil Spill Planning and Response Activities Under the Federal Water Pollution Control Act's National Oil and Hazardous Substances Pollution Contingency Plan and the Endangered Species Act using the Planning Template contained in Appendix C of that Agreement.

Report Oil Spills and Chemical Releases Toll Free
1-800 424-8802

Thank you for your efforts in this matter. If you require additional information, please contact CDR Bill Robberson, US EPA Regional Response Team IX Coordinator, at (415) 972-3072.

Sincerely,



Mr. Dan Meer,
EPA RRT-IX Co-Chair

Captain Gerald Swanson,
USCG RRT-IX Co-Chair

Attached: Biological Assessment – Impacts to Species listed or Proposed for listing
under the Federal Endangered Species Act

Cc: Mr. Michael Sowby, California DFG, OSPR
Ms. Patricia S. Port, REO, Department of the Interior



UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE

Southwest Region
501 West Ocean Boulevard, Suite 4200
Long Beach, California 90802-4213
In Reply Refer To:
F/SWR3:JJD

AUG 18 2003

Captain Steve Thompson
DOC/NOAA Representative
Regional Response Team IX
Ft. Mason, Bldg 201
San Francisco, California 94123

Dear Captain Thompson,

Thank you for contacting the Southwest Region (SWR) oil spill response representative, Mr. Joe Dillon in our Santa Rosa Area Office, and asking for written clarification regarding the Southwest Region's position on the use of oil dispersants in the event of a spill in federal waters off the California coast. As you are aware through your coordination activities with Joe the last few years, we support the use of the latest formulations of oil spill dispersants, Corexit 9527 and Corexit 9500, to prevent the migration of spilled oil to sensitive habitats such as estuaries, rookeries and the intertidal region. In areas such as these, oil may permeate the substrate resulting in long term exposure of NOAA trust resources to the oil and its degradation products.

The Northwest Region (NWR) of NOAA's National Marine Fisheries Service concluded an Endangered Species Act (ESA) section 7 consultation for oil spill response activities in November 2003. This consultation considered the potential effects of dispersant use on large whales, Steller sea lions and salmonids. These ESA listed species also occur in the Southwest Region as well as several species of sea turtles and the white abalone. Section 7 consultation for the various oil spill response options has not been conducted in the SWR.

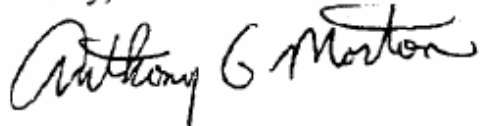
The use of the two dispersants mentioned above was analyzed as part of the NWR's biological opinion. The biological opinion reviewed numerous studies related to the toxicity and fate of oil and oil treated with dispersants. It concluded that the Corexit dispersants are much less toxic than most oils such that the primary factor leading to any toxic response in a spill situation is the oil itself. Field trials conducted by the National Ocean Service (NOS) have shown that dispersed oil does not penetrate below approximately 10 meters in depth in measurable concentrations. These same field trials found that the mean peak concentration of dispersed oil (10.8 parts per million (ppm) with a range of 2.2 ppm to 53.8 ppm) was reached about one hour from the application of dispersants. The concentrations rapidly declined past this point in time. Dispersed oil concentrations were not likely to exceed one ppm at depths of 10 meters or greater.



The use of the Corexit dispersants does not measurably add to the risk of effects to listed species exposed during an oil spill event. In many cases the use of dispersants helps mitigate the potential effects by reducing the time the oil spends on the surface of the water where the most vulnerable marine animals (i.e. fur seals and birds) may be exposed. The biological opinion concluded with the determination that the likelihood that response options will exacerbate the effects of oil spills is minimal. Rather, they collectively benefit listed species and habitat through minimizing the greater environmental risk from spills. The SWR has shared this opinion of oil spill response, including the use of the latest formulations of dispersants, for many years. We plan to stay up to date with developments in the field by continuing to work with the NOS and the Regional Response Team.

We would also like to take this opportunity to thank you for your efforts over the last three years to coordinate with Joe as he was assigned this duty. We hope this coordination will continue with your expected replacement as well as the new NOS Scientific Support Coordinator when that vacant position is eventually filled. We feel there is still work to be done in oil spill planning in the SWR to maximize protection to all NOAA resources and look forward to continuing the process.

Sincerely,



for ^{*} Rodney McInnis
Regional Administrator

Cc: Bill Robberson, USEPA Region IX, San Francisco, California
Mike Sowby, CDFG OSPR, Sacramento, California
Val Chambers, NMFS, Long Beach, California
Scott Hill, NMFS, Long Beach, California
Steve Edmondson, NMFS, Santa Rosa, California
Michael Aceituno, NMFS, Sacramento, California
Dick Butler, NMFS, Santa Rosa, California
Irma Lagomarsino, NMFS, Arcata, California
Craig Wingert, NMFS, Long Beach, California
Joe Dillon, NMFS, Santa Rosa, California

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APPENDIX K

UNIT CONVERSIONS

Volume

1 U.S. Gallon (gal) = 231 in³ = 0.1337 ft³
1 barrel(s) (bbl) = 42 U.S. gal = 5.615 ft³
1 bbl = 158.97 liter (L) = 0.159 m³
1 U.S. gal = 3.785 L
1 L = 0.26 gal
1 tonne of oil = 1000 L = 1m³ = ~ 264 gal
1 m³ = 6.29 bbl = 264.2 gal
1 ft³ = 0.0283 m³ = 7.48 gal
1 m³ = 10⁶ cm³ = 10³ L
1 Imperial gal = 1.2 U.S. gal
1 U.S. gal = 0.83 Imperial gal

Length

1 inch = 2.54 cm
1 ft = 30.38 cm
1 ft = 0.3048 m
1 m = 3.2808 feet
1 statute mile = 0.87 nautical mile (nm)
1 mile = 1610 m = 5280 ft
1 nm = 6076 feet
1 km = 0.54 nm
1 nm = 1.852 km = 1852 m
1 nm = 1.15 statute miles
1 micron = m x 10⁻⁶ = mm x 10⁻³
1 fathom (6 ft) = 1.829 m
1 m = 0.547 fathoms

Volume Rate

L/hr x 0.0063 = bbl/hr
L/hr x 0.0044 = gpm
tonnes/hr (or m³/hr) x 4.4 = gpm
tonnes/hr x 6.3 = bbl/hr
bbl/hr x 0.7 = gpm

L/sec x 15.9 = gpm

gpm x 34.29 = bbl/day
m³/hr x 16.7 = L/min
L/min x 0.06 = m³/hr
gpm x 3.78 = L/min
bbl/day x 0.11 = L/min
bbl/day x 0.0292 = gpm

Distance Rate

1 knot = 1.69 ft/sec
1 knot = 1.94 m/sec = 1.13 miles/hr
ft/sec x 0.593 = knots
m/sec x 1.94 = knots
miles per hour (mph) x 1.5 = ft/sec

knots (kts) x 51.4 = cm/sec

Area

1 hectare = 10000 m² = 100m²
1 acre = 43560 ft² = 0.4047 hectares = 247 km²
1 acre = 4047 m²
1 hectare = 2.471 acres
1 ft² = 0.0929 m²
1 mile² = 2.59 km²
1 nm² = 847 acres

Weight

1 pound (lb) = 0.45 kilograms (kg)
1 kg = 2.2 lb
lb/ft x 1.48 = kg/m
kg/m x 0.672 = lb/ft
1 metric ton = 1000 kg (~ 1 long ton)

From ExxonMobil, 2000

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APPENDIX L

ABBREVIATIONS AND ACRONYMS

AC	Area Committee
ACP	Area Contingency Plan
ADP	Area Dispersant Plan
ADIOS	Automated Data Inquiry for Oil Spills
API	American Petroleum Institute
ASTM	American Society for Testing and Materials
AZ	Arizona
CA	California
CDNMS	Cordell Bank National Marine Sanctuary
CCC	California Coastal Commission
CDFG	California Department of Fish and Game
CDP	California Dispersant Plan
CINMS	Channel Islands National Marine Sanctuary
COTP	Captain of the Port
CZMA	Coastal Zone Management Act
DOC	Department of Commerce
DOI	Department of Interior
DUP	Dispersant Use Policy
EADC	Emergency Aerial Dispersant Consortium
EFH	Essential Fish Habitat
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ETA	Estimated Time of Arrival
ETD	Estimated Time of Departure
FOSC	Federal On –Scene Coordinator
GFNMS	Gulf of the Farallons National Marine Sanctuary
GIS	Geographic Information System
GPS	Global Positioning System
HCPB	Habitat Conservation Planning Branch
LA	Los Angeles
MBNSM	Monterey Bay National Marine Sanctuary
MMPA	Marine Mammal Protection Act
MSDS	Material Safety Data Sheet
NCP	National Contingency Plan
NEBA	Net Environmental Benefit Analysis
NMFS	National Marine Fisheries Service
NMS	National Marine Sanctuary
NOAA	National Oceanic and Atmospheric Administration
NRC	National Response Center <u>or</u> National Response Corporation
OCS	Outer Continental Shelf
OWCN	Oiled Wildlife Care Network
OSCA	Oil Spill Cleanup Agent
OSPR	Office of Spill Prevention and Response
OSRO	Oil Spill Response (or Removal) Organization
PPE	Personal Protective Equipment
PST	Pacific Standard Time
RCP	Regional Contingency Plan
RRT	Regional Response Team
SCB	Southern California Bight
SMART	Special Monitoring of Advanced Response Technologies
SSC	Scientific Support Coordinator

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APPENDIX M

GLOSSARY

ADIOS

Automated Data Inquiry for Oil Spills. A NOAA computer database listing the characteristics of crude oils and refined products, and predicting expected characteristics and behavior of oil spilled into the marine environment.

API gravity

A scale for measuring fluid specific gravities based on an inverse relationship with specific gravity.

Black oil

A black or very dark brown layer of oil, sometimes with a latex texture. Depending on the quantity spilled, oil tends to quickly spread out over the water surface to a thickness of about 1 millimeter (0.04 inches). Can look like kelp and other natural phenomena. From the air, it is impossible to tell how thick a black oil layer is.

Brown oil

Water-in-oil emulsion. Thickness typically is 0.1 to 1.0 millimeters, but will vary depending on wind and current conditions. Usually has a heavy or dull sheen. Brown oil can be easily confused with algal scum collecting in convergence lines, algae patches, or kelp.

Centistoke (cSt)

A unit of measurement used in defining the kinematic viscosity of a fluid.

Chemical dispersant

A chemical formulation containing surface active agents (surfactants) that lower the surface tension between oil and water, promoting the formation of oil droplets and reducing the tendency of oil to stick to other droplets or surfaces, thereby enhancing dispersion into the water column.

Clean up

Actions taken to prevent further oil releases, protect areas from oil damage, mitigate oil effects (*e.g.*, through deflection, containment, collection, chemical dispersion, or bioremediation), and clean up of oil-contaminated areas and wildlife where monitoring shows a net environmental benefit in doing so.

Coastal waters

The territorial sea from the shoreline high water mark and then offshore to 12 nautical miles.

Continental waters

The coastal waters (high water mark to 12 nautical miles offshore) and the Exclusive Economic Zone (12 to 200 nautical miles offshore), and all water over the continental shelf.

Contingency plan

An action plan prepared in anticipation of an oil spill for a site or region, containing guidelines and operating instructions to facilitate efficient and effective clean up operations, and to protect areas of biological, social and economic importance. Contingency plans affecting response planning and response in California include Area Contingency Plans (federally directed by the Oil Pollution Act of 1990, covering marine response in federal waters (3 – 200 nautical miles from shore) throughout California, and with the greatest regional detail), the State Contingency Plan (California state directed by the Lempert-Keene-Seastrand Act, covering California response in state waters (0-3 nautical miles from shore), the Regional Contingency Plan (federally directed and managed by the Region IX Regional

Response Team, covering marine and inland response in several western states), and the National Contingency Plan (federal directed and covering national response in marine and inland waters).

Convergence line

A line on the water surface where floating objects and oil collect. A convergence can be the interface between two different types or bodies of water, or it can be caused by a significant depth change, tidal changes, or other common phenomena. Convergences are common in the marine environment.

Dispersion

The breaking up of an oil slick into small droplets that are mixed into the water column by breaking waves and other sea surface turbulence.

Emulsification

The formation of a water-in-oil mixture. Different oils exhibit different tendencies to emulsify, and emulsification is more likely to occur under high energy conditions (strong winds and waves). An emulsified mixture of water in oil is commonly called “mousse”; its presence indicates a spill that has been on the water for some time.

Entrainment

The loss of oil from containment when it is pulled under a boom by a strong current. Entrainment typically occurs from booms deployed perpendicular to currents greater than 1 knot (0.5 meters per second).

Flash point

(see volatility)

Mousse

An emulsified mixture of water in oil. Mousse can range in color from dark brown to nearly red or tan, and typically has a thickened or pudding-like consistency compared to fresh oil. Incorporation of up to 75 percent water into the oil will cause the apparent volume of a given quantity of oil to increase by up to four times.

Pancakes

Isolated, roughly circular patches of oil ranging in size from a few feet across to hundreds of yards (or meters) in diameter. Sheen may or may not also be present.

Persistent oil

Oils and petroleum products such as crude oils, fuel oils and lubrication oils that, when spilled, remain in a residual form in the environment for an appreciable period.

Plume

Oil that is dispersing into the water column as a cloud of small droplets.

Pour point

The temperature below which oil will not flow.

Recoverable oil

Oil in a thick enough layer on the water to be recovered by conventional techniques and mechanical equipment. Only black or dark brown oil, mousse, and heavy sheens (which are dull brown in color) are generally considered to be thick enough to be effectively recovered by skimmers.

Sheen

A very thin layer of oil floating on the water surface. Sheen is the most commonly-observed form of oil during the later stages of a spill. Depending on thickness, sheens range in color from dull brown for the thickest sheens to rainbow, gray, silver and near-transparent in the case of the thinnest sheens.

- A light sheen is almost transparent, and is sometimes confused with windrows and natural sheen resulting from biological processes.
- A silver sheen is a slightly thicker layer of oil that appears silvery or shimmers; occasionally called gray sheen.
- A rainbow sheen reflects colors.

Slick

Oil spilled on the water, which absorbs energy and dampens out surface waves, making the oil appear smoother – or slicker – than the surrounding water.

SMART

Special Monitoring of Applied Response Technologies. A cooperatively designed monitoring program for *in situ* burning and dispersants. SMART relies on small, highly mobile teams to collect real-time data, which are subsequently channeled to the Unified Command to address critical questions, such as whether dispersants are effective in dispersing the oil.

Specific gravity

The ratio of the mass of oil to the mass of freshwater, when both are of the same volume and temperature.

Streamers

A narrow line of oil, mousse, or sheen on the water surface, surrounded on both sides by clean water. Streamers result from the combined effects of wind, currents, and/or natural convergence zones. Often, heavier concentrations of mousse or sheen will be present in the center of a streamer, with progressively lighter sheen along the edges. Streamers are also often called “fingers” or “ribbons”.

Tarballs

Weathered oil that has formed pliable balls or patches that float on the water. Tarballs can range in diameter from a few millimeters (much less than an inch) to a foot (0.3 meters). Sheen may or may not be present, depending on how weathered or hardened the outer layer of the tarball is.

Tarmats

Non-floating mats of oily debris (usually sediment and/or plant matter) that are found on beaches or in shallow water just offshore.

Unified Command

Representatives of the spiller, the federal government, and state government, who are collectively in charge of the spill response. For California marine spills, the federal representative is the U.S. Coast Guard and the state representative is the California Department of Fish and Game Office of Spill Prevention and Response.

Viscosity

An oil’s internal resistance to flow. Highly viscous oil will not flow easily.

Volatility

A property of a liquid that has a low boiling point and a high vapor pressure at ordinary pressures and temperatures.

Water-in-oil emulsion

(see mousse)

Weathering

A combination of physical and environmental processes, such as evaporation, dissolution, dispersion, and emulsification, which act on spilled oil to change its physical properties and composition.

Window of opportunity

The period of time available for undertaking a particular response. For example, the application of dispersant before the oil emulsifies to a stage where dispersant becomes ineffective.

Windrows

Streaks of oil that line up in the direction of the wind. Windrows typically form early during a spill when the wind speed is at least 10 knots (5.1 meters per second). Sheen is the form of spilled oil that most frequently forms windrows.

California Dispersant Plan Appendix N

MSDS (Material Safety Data Sheets) for Dispersants

Dispersants:

COREXIT (R) EC9500A

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COREXIT (R) EC9527A

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**SAFETY DATA SHEET****PRODUCT****COREXIT (R) EC9500A****EMERGENCY TELEPHONE NUMBER(S)****(800) 424-9300 (24 Hours) CHEMTREC****1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION****PRODUCT NAME :** **COREXIT (R) EC9500A****APPLICATION :** **OIL SPILL DISPERSANT****COMPANY IDENTIFICATION :** Nalco Company
1601 W. Diehl Road
Naperville, Illinois
60563-1198**EMERGENCY TELEPHONE NUMBER(S) :** (800) 424-9300 (24 Hours) CHEMTREC

NFPA 704M/HMIS RATING

HEALTH : 1 / 1 **FLAMMABILITY :** 1 / 1 **INSTABILITY :** 0 / 0 **OTHER :**

0 = Insignificant 1 = Slight 2 = Moderate 3 = High 4 = Extreme

2. COMPOSITION/INFORMATION ON INGREDIENTS

Our hazard evaluation has identified the following chemical substance(s) as hazardous. Consult Section 15 for the nature of the hazard(s).

Hazardous Substance(s)	CAS NO	% (w/w)
Distillates, petroleum, hydrotreated light	64742-47-8	10.0 - 30.0
Propylene Glycol	57-55-6	1.0 - 5.0
Organic sulfonic acid salt	Proprietary	10.0 - 30.0

3. HAZARDS IDENTIFICATION****EMERGENCY OVERVIEW******CAUTION**

May cause irritation with prolonged contact.

Keep away from heat. Keep away from sources of ignition - No smoking. Keep container tightly closed. Do not get in eyes, on skin, on clothing. Do not take internally. Avoid breathing vapor. Use with adequate ventilation. In case of contact with eyes, rinse immediately with plenty of water and seek medical advice. After contact with skin, wash immediately with plenty of soap and water.

Wear suitable protective clothing.

Low Fire Hazard; liquids may burn upon heating to temperatures at or above the flash point. May evolve oxides of carbon (COx) under fire conditions. May evolve oxides of sulfur (SOx) under fire conditions.

PRIMARY ROUTES OF EXPOSURE :

Eye, Skin

HUMAN HEALTH HAZARDS - ACUTE :**EYE CONTACT :**

Can cause mild irritation.

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SKIN CONTACT :

May cause irritation with prolonged contact.

INGESTION :

Not a likely route of exposure. May cause nausea and vomiting. Can cause chemical pneumonia if aspirated into lungs following ingestion.

INHALATION :

Repeated or prolonged exposure may irritate the respiratory tract.

SYMPTOMS OF EXPOSURE :

Acute :

A review of available data does not identify any symptoms from exposure not previously mentioned.

Chronic :

Frequent or prolonged contact with product may defat and dry the skin, leading to discomfort and dermatitis.

AGGRAVATION OF EXISTING CONDITIONS :

Skin contact may aggravate an existing dermatitis condition.

4. FIRST AID MEASURES

EYE CONTACT :

Flush affected area with water. Get medical attention.

SKIN CONTACT :

Flush affected area with water. If symptoms develop, seek medical advice.

INGESTION :

Do not induce vomiting: contains petroleum distillates and/or aromatic solvents. If conscious, washout mouth and give water to drink. Get medical attention.

INHALATION :

Remove to fresh air, treat symptomatically. Get medical attention.

NOTE TO PHYSICIAN :

Based on the individual reactions of the patient, the physician's judgement should be used to control symptoms and clinical condition.

5. FIRE FIGHTING MEASURES

FLASH POINT : 181.4 °F / 83 °C (PMCC)

This product does not sustain combustion per the method outlined in 49 CFR Appendix H.

LOWER EXPLOSION LIMIT : Not flammable

UPPER EXPLOSION LIMIT : Not flammable

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EXTINGUISHING MEDIA :

Alcohol foam, Carbon dioxide, Foam, Dry powder, Other extinguishing agent suitable for Class B fires, For large fires, use water spray or fog, thoroughly drenching the burning material.
Water mist may be used to cool closed containers.

UNSUITABLE EXTINGUISHING MEDIA :

Do not use water unless flooding amounts are available.

FIRE AND EXPLOSION HAZARD :

Low Fire Hazard; liquids may burn upon heating to temperatures at or above the flash point. May evolve oxides of carbon (COx) under fire conditions. May evolve oxides of sulfur (SOx) under fire conditions.

SPECIAL PROTECTIVE EQUIPMENT FOR FIRE FIGHTING :

In case of fire, wear a full face positive-pressure self contained breathing apparatus and protective suit.

6. ACCIDENTAL RELEASE MEASURES

PERSONAL PRECAUTIONS :

Restrict access to area as appropriate until clean-up operations are complete. Stop or reduce any leaks if it is safe to do so. Ventilate spill area if possible. Do not touch spilled material. Remove sources of ignition. Have emergency equipment (for fires, spills, leaks, etc.) readily available. Use personal protective equipment recommended in Section 8 (Exposure Controls/Personal Protection). Notify appropriate government, occupational health and safety and environmental authorities.

METHODS FOR CLEANING UP :

SMALL SPILLS: Soak up spill with absorbent material. Place residues in a suitable, covered, properly labeled container. Wash affected area. **LARGE SPILLS:** Contain liquid using absorbent material, by digging trenches or by diking. Reclaim into recovery or salvage drums or tank truck for proper disposal. Clean contaminated surfaces with water or aqueous cleaning agents. Contact an approved waste hauler for disposal of contaminated recovered material. Dispose of material in compliance with regulations indicated in Section 13 (Disposal Considerations).

ENVIRONMENTAL PRECAUTIONS :

Do not contaminate surface water.

7. HANDLING AND STORAGE

HANDLING :

Use with adequate ventilation. Keep the containers closed when not in use. Do not take internally. Do not get in eyes, on skin, on clothing. Have emergency equipment (for fires, spills, leaks, etc.) readily available.

STORAGE CONDITIONS :

Store away from heat and sources of ignition. Store separately from oxidizers. Store the containers tightly closed.

SUITABLE CONSTRUCTION MATERIAL :

Compatibility with Plastic Materials can vary; we therefore recommend that compatibility is tested prior to use., Stainless Steel 304, Stainless Steel 316L, Aluminum, Hastelloy C-276, MDPE (medium density polyethylene), HDPE (high density polyethylene), PVC, Plexiglass, Teflon, Kalrez, Perfluoroelastomer, PTFE, TFE, FEP (encapsulated)

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UNSUITABLE CONSTRUCTION MATERIAL :

Mild steel, Carbon steel, Buna-N, Brass, Copper, Natural rubber, Polyethylene, Polypropylene, Ethylene propylene, EPDM, Neoprene, Nitrile, Polyurethane, Viton, Alfax, Hypalon

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

OCCUPATIONAL EXPOSURE LIMITS :

Exposure guidelines have not been established for this product. Available exposure limits for the substance(s) are shown below.

ACGIH/TLV :

Substance(s)

Oil Mist (Mineral)

TWA: 5 mg/m³

STEL: 10 mg/m³

OSHA/PEL :

Substance(s)

Oil Mist (Mineral)

TWA: 5 mg/m³

AIHA/WEEL :

Substance(s)

Propylene Glycol

TWA: 10 mg/m³

ENGINEERING MEASURES :

General ventilation is recommended.

RESPIRATORY PROTECTION :

Where concentrations in air may exceed the limits given in this section, the use of a half face filter mask or air supplied breathing apparatus is recommended. A suitable filter material depends on the amount and type of chemicals being handled. Consider the use of filter type: Multi-contaminant cartridge. with a Particulate pre-filter. In event of emergency or planned entry into unknown concentrations a positive pressure, full-facepiece SCBA should be used. If respiratory protection is required, institute a complete respiratory protection program including selection, fit testing, training, maintenance and inspection.

HAND PROTECTION :

Nitrile gloves, PVC gloves

SKIN PROTECTION :

Wear standard protective clothing.

EYE PROTECTION :

Wear chemical splash goggles.

HYGIENE RECOMMENDATIONS :

Keep an eye wash fountain available. Keep a safety shower available. If clothing is contaminated, remove clothing and thoroughly wash the affected area. Launder contaminated clothing before reuse.

**SAFETY DATA SHEET****PRODUCT****COREXIT (R) EC9500A****EMERGENCY TELEPHONE NUMBER(S)****(800) 424-9300 (24 Hours) CHEMTREC****HUMAN EXPOSURE CHARACTERIZATION :**

Based on our recommended product application and personal protective equipment, the potential human exposure is: Low

9. PHYSICAL AND CHEMICAL PROPERTIES

PHYSICAL STATE	Liquid
APPEARANCE	Clear Hazy Amber
ODOR	Hydrocarbon
SPECIFIC GRAVITY	0.95 @ 60 °F / 15.6 °C
DENSITY	7.91 lb/gal
SOLUBILITY IN WATER	Miscible
pH (100 %)	6.2
VISCOSITY	177 cst @ 32 °F / 0 °C 70 cst @ 60 °F / 15.6 °C
POUR POINT	< -71 °F / < -57 °C
BOILING POINT	296 °F / 147 °C
VAPOR PRESSURE	15.5 mm Hg @ 100 °F / 37.8 °C

Note: These physical properties are typical values for this product and are subject to change.

10. STABILITY AND REACTIVITY**STABILITY :**

Stable under normal conditions.

HAZARDOUS POLYMERIZATION :

Hazardous polymerization will not occur.

CONDITIONS TO AVOID :

Heat and sources of ignition including static discharges.

MATERIALS TO AVOID :

Contact with strong oxidizers (e.g. chlorine, peroxides, chromates, nitric acid, perchlorate, concentrated oxygen, permanganate) may generate heat, fires, explosions and/or toxic vapors.

HAZARDOUS DECOMPOSITION PRODUCTS :

Under fire conditions: Oxides of carbon, Oxides of sulfur

11. TOXICOLOGICAL INFORMATION

No toxicity studies have been conducted on this product.

SENSITIZATION :

This product is not expected to be a sensitizer.

**SAFETY DATA SHEET****PRODUCT****COREXIT (R) EC9500A****EMERGENCY TELEPHONE NUMBER(S)****(800) 424-9300 (24 Hours) CHEMTREC****CARCINOGENICITY :**

None of the substances in this product are listed as carcinogens by the International Agency for Research on Cancer (IARC), the National Toxicology Program (NTP) or the American Conference of Governmental Industrial Hygienists (ACGIH).

HUMAN HAZARD CHARACTERIZATION :

Based on our hazard characterization, the potential human hazard is: Moderate

12. ECOLOGICAL INFORMATION**ECOTOXICOLOGICAL EFFECTS :**

The following results are for the product.

ACUTE INVERTEBRATE RESULTS :

Species	Exposure	LC50	EC50	Test Descriptor
Acartia tonsa	48 hrs	34 mg/l		Product
Artemia	48 hrs	20.7 mg/l		Product

MOBILITY :

The environmental fate was estimated using a level III fugacity model embedded in the EPI (estimation program interface) Suite TM, provided by the US EPA. The model assumes a steady state condition between the total input and output. The level III model does not require equilibrium between the defined media. The information provided is intended to give the user a general estimate of the environmental fate of this product under the defined conditions of the models.

If released into the environment this material is expected to distribute to the air, water and soil/sediment in the approximate respective percentages;

Air	Water	Soil/Sediment
<5%	10 - 30%	50 - 70%

The portion in water is expected to float on the surface.

BIOACCUMULATION POTENTIAL

Component substances have a potential to bioaccumulate.

ENVIRONMENTAL HAZARD AND EXPOSURE CHARACTERIZATION

Based on our hazard characterization, the potential environmental hazard is: Low

Based on our recommended product application and the product's characteristics, the potential environmental exposure is: Low

If released into the environment, see CERCLA/SUPERFUND in Section 15.

13. DISPOSAL CONSIDERATIONS

If this product becomes a waste, it could meet the criteria of a hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA) 40 CFR 261. Before disposal, it should be determined if the waste meets the criteria of a hazardous waste.

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Hazardous Waste: D018

Hazardous wastes must be transported by a licensed hazardous waste transporter and disposed of or treated in a properly licensed hazardous waste treatment, storage, disposal or recycling facility. Consult local, state, and federal regulations for specific requirements.

14. TRANSPORT INFORMATION

The information in this section is for reference only and should not take the place of a shipping paper (bill of lading) specific to an order. Please note that the proper Shipping Name / Hazard Class may vary by packaging, properties, and mode of transportation. Typical Proper Shipping Names for this product are as follows.

LAND TRANSPORT :

Proper Shipping Name :

PRODUCT IS NOT REGULATED DURING TRANSPORTATION**AIR TRANSPORT (ICAO/IATA) :**

Proper Shipping Name :

PRODUCT IS NOT REGULATED DURING TRANSPORTATION**MARINE TRANSPORT (IMDG/IMO) :**

Proper Shipping Name :

PRODUCT IS NOT REGULATED DURING TRANSPORTATION**15. REGULATORY INFORMATION**

This section contains additional information that may have relevance to regulatory compliance. The information in this section is for reference only. It is not exhaustive, and should not be relied upon to take the place of an individualized compliance or hazard assessment. Nalco accepts no liability for the use of this information.

NATIONAL REGULATIONS, USA :**OSHA HAZARD COMMUNICATION RULE, 29 CFR 1910.1200 :**

Based on our hazard evaluation, the following substance(s) in this product is/are hazardous and the reason(s) is/are shown below.

Distillates, petroleum, hydrotreated light : Irritant

Propylene Glycol : Exposure Limit

Organic sulfonic acid salt : Irritant

CERCLA/SUPERFUND, 40 CFR 117, 302 :

Notification of spills of this product is not required.



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SARA/SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT OF 1986 (TITLE III) - SECTIONS 302, 311, 312, AND 313 :

SECTION 302 - EXTREMELY HAZARDOUS SUBSTANCES (40 CFR 355) :

This product does not contain substances listed in Appendix A and B as an Extremely Hazardous Substance.

SECTIONS 311 AND 312 - MATERIAL SAFETY DATA SHEET REQUIREMENTS (40 CFR 370) :

Our hazard evaluation has found this product to be hazardous. The product should be reported under the following indicated EPA hazard categories:

- | | |
|---|-----------------------------------|
| X | Immediate (Acute) Health Hazard |
| - | Delayed (Chronic) Health Hazard |
| - | Fire Hazard |
| - | Sudden Release of Pressure Hazard |
| - | Reactive Hazard |

Under SARA 311 and 312, the EPA has established threshold quantities for the reporting of hazardous chemicals. The current thresholds are: 500 pounds or the threshold planning quantity (TPQ), whichever is lower, for extremely hazardous substances and 10,000 pounds for all other hazardous chemicals.

SECTION 313 - LIST OF TOXIC CHEMICALS (40 CFR 372) :

This product does not contain substances on the List of Toxic Chemicals.

TOXIC SUBSTANCES CONTROL ACT (TSCA) :

The substances in this preparation are included on or exempted from the TSCA 8(b) Inventory (40 CFR 710)

FEDERAL WATER POLLUTION CONTROL ACT, CLEAN WATER ACT, 40 CFR 401.15 / formerly Sec. 307, 40 CFR 116.4 / formerly Sec. 311 :

None of the substances are specifically listed in the regulation.

CLEAN AIR ACT, Sec. 112 (40 CFR 61, Hazardous Air Pollutants), Sec. 602 (40 CFR 82, Class I and II Ozone Depleting Substances) :

None of the substances are specifically listed in the regulation.

CALIFORNIA PROPOSITION 65 :

This product does not contain substances which require warning under California Proposition 65.

MICHIGAN CRITICAL MATERIALS :

None of the substances are specifically listed in the regulation.

STATE RIGHT TO KNOW LAWS :

The following substances are disclosed for compliance with State Right to Know Laws:

Propylene Glycol

57-55-6

NATIONAL REGULATIONS, CANADA :

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WORKPLACE HAZARDOUS MATERIALS INFORMATION SYSTEM (WHMIS) :

This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all the information required by the CPR.

A claim has been submitted to the Hazardous Materials Information Review Commission (HMIRC) for exemption from disclosure of a substance.

HMIRC Registry Number : 6639

Filed : 06/01/2006

WHMIS CLASSIFICATION :

B3 - Combustible Liquids

CANADIAN ENVIRONMENTAL PROTECTION ACT (CEPA) :

The substance(s) in this preparation are included in or exempted from the Domestic Substance List (DSL).

AUSTRALIA

All substances in this product comply with the National Industrial Chemicals Notification & Assessment Scheme (NICNAS).

CHINA

All substances in this product comply with the Chemical Control Law and are listed on the Inventory of Existing Chemical Substances China (IECSC).

EUROPE

The substance(s) in this preparation are included in or exempted from the EINECS or ELINCS inventories

JAPAN

All substances in this product comply with the Law Regulating the Manufacture and Importation Of Chemical Substances and are listed on the Ministry of International Trade & Industry List (MITI).

KOREA

All substances in this product comply with the Toxic Chemical Control Law (TCCL) and are listed on the Existing Chemicals List (ECL)

PHILIPPINES

All substances in this product comply with the Republic Act 6969 (RA 6969) and are listed on the Philippines Inventory of Chemicals & Chemical Substances (PICCS).

16. OTHER INFORMATION

Due to our commitment to Product Stewardship, we have evaluated the human and environmental hazards and exposures of this product. Based on our recommended use of this product, we have characterized the product's general risk. This information should provide assistance for your own risk management practices. We have evaluated our product's risk as follows:

* The human risk is: Low

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* The environmental risk is: Low

Any use inconsistent with our recommendations may affect the risk characterization. Our sales representative will assist you to determine if your product application is consistent with our recommendations. Together we can implement an appropriate risk management process.

This product material safety data sheet provides health and safety information. The product is to be used in applications consistent with our product literature. Individuals handling this product should be informed of the recommended safety precautions and should have access to this information. For any other uses, exposures should be evaluated so that appropriate handling practices and training programs can be established to insure safe workplace operations. Please consult your local sales representative for any further information.

REFERENCES

Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices, American Conference of Governmental Industrial Hygienists, OH., (Ariel InsightTM CD-ROM Version), Ariel Research Corp., Bethesda, MD.

Hazardous Substances Data Bank, National Library of Medicine, Bethesda, Maryland (TOMES CPSTM CD-ROM Version), Micromedex, Inc., Englewood, CO.

IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man, Geneva: World Health Organization, International Agency for Research on Cancer.

Integrated Risk Information System, U.S. Environmental Protection Agency, Washington, D.C. (TOMES CPSTM CD-ROM Version), Micromedex, Inc., Englewood, CO.

Annual Report on Carcinogens, National Toxicology Program, U.S. Department of Health and Human Services, Public Health Service.

Title 29 Code of Federal Regulations, Part 1910, Subpart Z, Toxic and Hazardous Substances, Occupational Safety and Health Administration (OSHA), (Ariel InsightTM CD-ROM Version), Ariel Research Corp., Bethesda, MD.

Registry of Toxic Effects of Chemical Substances, National Institute for Occupational Safety and Health, Cincinnati, OH, (TOMES CPSTM CD-ROM Version), Micromedex, Inc., Englewood, CO.

Ariel InsightTM (An integrated guide to industrial chemicals covered under major regulatory and advisory programs), North American Module, Western European Module, Chemical Inventories Module and the Generics Module (Ariel InsightTM CD-ROM Version), Ariel Research Corp., Bethesda, MD.

The Teratogen Information System, University of Washington, Seattle, WA (TOMES CPSTM CD-ROM Version), Micromedex, Inc., Englewood, CO.

Prepared By : Product Safety Department
Date issued : 10/22/2008
Version Number : 1.13

**SAFETY DATA SHEET****PRODUCT****COREXIT(R) EC9527A****EMERGENCY TELEPHONE NUMBER(S)****(800) 424-9300 (24 Hours) CHEMTREC****1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION****PRODUCT NAME :** COREXIT(R) EC9527A**APPLICATION :** OIL SPILL DISPERSANT**COMPANY IDENTIFICATION :** Nalco Company
1601 W. Diehl Road
Naperville, Illinois
60563-1198**EMERGENCY TELEPHONE NUMBER(S) :** (800) 424-9300 (24 Hours) CHEMTREC

NFPA 704M/HMIS RATING

HEALTH : 2 / 2 FLAMMABILITY : 1 / 1 INSTABILITY : 0 / 0 OTHER :

0 = Insignificant 1 = Slight 2 = Moderate 3 = High 4 = Extreme

2. COMPOSITION/INFORMATION ON INGREDIENTS

Our hazard evaluation has identified the following chemical substance(s) as hazardous. Consult Section 15 for the nature of the hazard(s).

Hazardous Substance(s)	CAS NO	% (w/w)
2-Butoxyethanol	111-76-2	30.0 - 60.0
Organic sulfonic acid salt	Proprietary	10.0 - 30.0
Propylene Glycol	57-55-6	1.0 - 5.0

3. HAZARDS IDENTIFICATION****EMERGENCY OVERVIEW******WARNING**

Eye and skin irritant. Repeated or excessive exposure to butoxyethanol may cause injury to red blood cells (hemolysis), kidney or the liver. Harmful by inhalation, in contact with skin and if swallowed.

Do not get in eyes, on skin, on clothing. Do not take internally. Use with adequate ventilation. Wear suitable protective clothing. Keep container tightly closed. Flush affected area with water. Keep away from heat. Keep away from sources of ignition - No smoking.

May evolve oxides of carbon (COx) under fire conditions.

PRIMARY ROUTES OF EXPOSURE :

Eye, Skin

HUMAN HEALTH HAZARDS - ACUTE :**EYE CONTACT :**

Can cause moderate irritation.

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SKIN CONTACT :

Can cause moderate irritation. Harmful if absorbed through skin.

INGESTION :

May be harmful if swallowed. May cause liver and kidney effects and/or damage. There may be irritation to the gastro-intestinal tract.

INHALATION :

Harmful by inhalation. Repeated or prolonged exposure may irritate the respiratory tract.

SYMPTOMS OF EXPOSURE :

Acute :

Excessive exposure may cause central nervous system effects, nausea, vomiting, anesthetic or narcotic effects.

Chronic :

Repeated or excessive exposure to butoxyethanol may cause injury to red blood cells (hemolysis), kidney or the liver.

AGGRAVATION OF EXISTING CONDITIONS :

Skin contact may aggravate an existing dermatitis condition.

HUMAN HEALTH HAZARDS - CHRONIC :

Contains ethylene glycol monobutyl ether (butoxyethanol). Prolonged and/or repeated exposure through inhalation or extensive skin contact with EGBE may result in damage to the blood and kidneys.

4. FIRST AID MEASURES

EYE CONTACT :

Flush affected area with water. Get medical attention.

SKIN CONTACT :

Flush affected area with water. Get medical attention.

INGESTION :

Do not induce vomiting without medical advice. If conscious, washout mouth and give water to drink. Get medical attention.

INHALATION :

Remove to fresh air, treat symptomatically. If symptoms develop, seek medical advice.

NOTE TO PHYSICIAN :

Based on the individual reactions of the patient, the physician's judgement should be used to control symptoms and clinical condition.

5. FIRE FIGHTING MEASURES

FLASH POINT : 163 °F / 72.7 °C (TCC)

This product does not sustain combustion per the method outlined in 49 CFR Appendix H.

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EXTINGUISHING MEDIA :

This product would not be expected to burn unless all the water is boiled away. The remaining organics may be ignitable. Use extinguishing media appropriate for surrounding fire.

FIRE AND EXPLOSION HAZARD :

May evolve oxides of carbon (COx) under fire conditions.

SPECIAL PROTECTIVE EQUIPMENT FOR FIRE FIGHTING :

In case of fire, wear a full face positive-pressure self contained breathing apparatus and protective suit.

6. ACCIDENTAL RELEASE MEASURES

PERSONAL PRECAUTIONS :

Restrict access to area as appropriate until clean-up operations are complete. Stop or reduce any leaks if it is safe to do so. Do not touch spilled material. Ventilate spill area if possible. Use personal protective equipment recommended in Section 8 (Exposure Controls/Personal Protection).

METHODS FOR CLEANING UP :

SMALL SPILLS: Soak up spill with absorbent material. Place residues in a suitable, covered, properly labeled container. Wash affected area. **LARGE SPILLS:** Contain liquid using absorbent material, by digging trenches or by diking. Reclaim into recovery or salvage drums or tank truck for proper disposal. Contact an approved waste hauler for disposal of contaminated recovered material. Dispose of material in compliance with regulations indicated in Section 13 (Disposal Considerations).

ENVIRONMENTAL PRECAUTIONS :

Do not contaminate surface water.

7. HANDLING AND STORAGE

HANDLING :

Avoid eye and skin contact. Do not take internally. Ensure all containers are labeled. Keep the containers closed when not in use.

STORAGE CONDITIONS :

Store the containers tightly closed.

SUITABLE CONSTRUCTION MATERIAL :

Stainless Steel 316L, Hastelloy C-276, MDPE (medium density polyethylene), Nitrile, Plexiglass, Kalrez, TFE, Alfax, Teflon, HDPE (high density polyethylene), Neoprene, Aluminum, Polypropylene, Polyethylene, Carbon Steel C1018, Stainless Steel 304, Compatibility with Plastic Materials can vary; we therefore recommend that compatibility is tested prior to use., FEP (encapsulated), Perfluoroelastomer, PVC

UNSUITABLE CONSTRUCTION MATERIAL :

Copper, Mild steel, Brass, Nylon, Buna-N, Natural rubber, Polyurethane, Hypalon, Viton, Ethylene propylene, EPDM



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8. EXPOSURE CONTROLS/PERSONAL PROTECTION

OCCUPATIONAL EXPOSURE LIMITS :

Exposure guidelines have not been established for this product. Available exposure limits for the substance(s) are shown below.

ACGIH/TLV :

Substance(s)

2-Butoxyethanol TWA: 20 ppm , 97 mg/m3

Propylene Glycol

OSHA/PEL :

Substance(s)

2-Butoxyethanol TWA: 50 ppm , 240 mg/m3 (Skin)

Propylene Glycol

AIHA/WEEL :

Substance(s)

For propylene glycol, an 8 hour TWA of 10 mg/m3 (aerosol) and 50 ppm (total).

ENGINEERING MEASURES :

General ventilation is recommended.

RESPIRATORY PROTECTION :

Where concentrations in air may exceed the limits given in this section, the use of a half face filter mask or air supplied breathing apparatus is recommended. A suitable filter material depends on the amount and type of chemicals being handled. Consider the use of filter type: Multi-contaminant cartridge. with a Particulate pre-filter. In event of emergency or planned entry into unknown concentrations a positive pressure, full-facepiece SCBA should be used. If respiratory protection is required, institute a complete respiratory protection program including selection, fit testing, training, maintenance and inspection.

HAND PROTECTION :

Neoprene gloves, Nitrile gloves, Butyl gloves, PVC gloves

SKIN PROTECTION :

Wear standard protective clothing.

EYE PROTECTION :

Wear chemical splash goggles.

HYGIENE RECOMMENDATIONS :

Keep an eye wash fountain available. Keep a safety shower available. If clothing is contaminated, remove clothing and thoroughly wash the affected area. Launder contaminated clothing before reuse.

HUMAN EXPOSURE CHARACTERIZATION :

Based on our recommended product application and personal protective equipment, the potential human exposure is: Low

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PHYSICAL STATE	Liquid
APPEARANCE	Clear Amber
ODOR	Mild
SPECIFIC GRAVITY	0.98 - 1.02
DENSITY	8.2 - 8.5 lb/gal
SOLUBILITY IN WATER	Complete
pH (100 %)	6.1
VISCOSITY	160 cst @ 32 °F / 0 °C
POUR POINT	ASTM D-97 -66.9 °F / -55 °C
POUR POINT	< -40 °F / < -40 °C
BOILING POINT	340 °F / 171 °C
VAPOR PRESSURE	< 5 mm Hg @ 100 °F / 38 °C Same as water
EVAPORATION RATE	0.1

Note: These physical properties are typical values for this product and are subject to change.

10. STABILITY AND REACTIVITY**STABILITY :**

Stable under normal conditions.

HAZARDOUS POLYMERIZATION :

Hazardous polymerization will not occur.

CONDITIONS TO AVOID :

Extremes of temperature

MATERIALS TO AVOID :

Contact with strong oxidizers (e.g. chlorine, peroxides, chromates, nitric acid, perchlorate, concentrated oxygen, permanganate) may generate heat, fires, explosions and/or toxic vapors.

HAZARDOUS DECOMPOSITION PRODUCTS :

Under fire conditions: Oxides of carbon

11. TOXICOLOGICAL INFORMATION

No toxicity studies have been conducted on this product.

SENSITIZATION :

This product is not expected to be a sensitizer.

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None of the substances in this product are listed as carcinogens by the International Agency for Research on Cancer (IARC), the National Toxicology Program (NTP) or the American Conference of Governmental Industrial Hygienists (ACGIH).

HUMAN HAZARD CHARACTERIZATION :

Based on our hazard characterization, the potential human hazard is: High

12. ECOLOGICAL INFORMATION**ECOTOXICOLOGICAL EFFECTS :**

No toxicity studies have been conducted on this product.

ACUTE FISH RESULTS :

Species	Exposure	LC50	Test Descriptor
Turbot	96 hrs	50 mg/l	

MOBILITY :

The environmental fate was estimated using a level III fugacity model embedded in the EPI (estimation program interface) Suite TM, provided by the US EPA. The model assumes a steady state condition between the total input and output. The level III model does not require equilibrium between the defined media. The information provided is intended to give the user a general estimate of the environmental fate of this product under the defined conditions of the models.

If released into the environment this material is expected to distribute to the air, water and soil/sediment in the approximate respective percentages;

Air	Water	Soil/Sediment
<5%	10 - 30%	70 - 90%

The portion in water is expected to be soluble or dispersible.

BIOACCUMULATION POTENTIAL

Component substances have a low potential to bioconcentrate.

ENVIRONMENTAL HAZARD AND EXPOSURE CHARACTERIZATION

Based on our hazard characterization, the potential environmental hazard is: Moderate

Based on our recommended product application and the product's characteristics, the potential environmental exposure is: Low

If released into the environment, see CERCLA/SUPERFUND in Section 15.

13. DISPOSAL CONSIDERATIONS

If this product becomes a waste, it is not a hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA) 40 CFR 261, since it does not have the characteristics of Subpart C, nor is it listed under Subpart D.



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As a non-hazardous waste, it is not subject to federal regulation. Consult state or local regulation for any additional handling, treatment or disposal requirements. For disposal, contact a properly licensed waste treatment, storage, disposal or recycling facility.

14. TRANSPORT INFORMATION

The information in this section is for reference only and should not take the place of a shipping paper (bill of lading) specific to an order. Please note that the proper Shipping Name / Hazard Class may vary by packaging, properties, and mode of transportation. Typical Proper Shipping Names for this product are as follows.

LAND TRANSPORT :

Proper Shipping Name : PRODUCT IS NOT REGULATED DURING TRANSPORTATION

AIR TRANSPORT (ICAO/IATA) :

Proper Shipping Name : PRODUCT IS NOT REGULATED DURING TRANSPORTATION

MARINE TRANSPORT (IMDG/IMO) :

Proper Shipping Name : PRODUCT IS NOT REGULATED DURING TRANSPORTATION

15. REGULATORY INFORMATION

This section contains additional information that may have relevance to regulatory compliance. The information in this section is for reference only. It is not exhaustive, and should not be relied upon to take the place of an individualized compliance or hazard assessment. Nalco accepts no liability for the use of this information.

NATIONAL REGULATIONS, USA :

OSHA HAZARD COMMUNICATION RULE, 29 CFR 1910.1200 :

Based on our hazard evaluation, none of the substances in this product are hazardous.

CERCLA/SUPERFUND, 40 CFR 117, 302 :

Notification of spills of this product is not required.

SARA/SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT OF 1986 (TITLE III) - SECTIONS 302, 311, 312, AND 313 :

SECTION 302 - EXTREMELY HAZARDOUS SUBSTANCES (40 CFR 355) :

This product does not contain substances listed in Appendix A and B as an Extremely Hazardous Substance.



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SECTIONS 311 AND 312 - MATERIAL SAFETY DATA SHEET REQUIREMENTS (40 CFR 370) :

Our hazard evaluation has found this product to be hazardous. The product should be reported under the following indicated EPA hazard categories:

- | | |
|---|-----------------------------------|
| X | Immediate (Acute) Health Hazard |
| X | Delayed (Chronic) Health Hazard |
| X | Fire Hazard |
| | Sudden Release of Pressure Hazard |
| | Reactive Hazard |

Under SARA 311 and 312, the EPA has established threshold quantities for the reporting of hazardous chemicals. The current thresholds are: 500 pounds or the threshold planning quantity (TPQ), whichever is lower, for extremely hazardous substances and 10,000 pounds for all other hazardous chemicals.

SECTION 313 - LIST OF TOXIC CHEMICALS (40 CFR 372) :

This product contains the following substance(s), (with CAS # and % range) which appear(s) on the List of Toxic Chemicals

<u>Hazardous Substance(s)</u>	<u>CAS NO</u>	<u>% (w/w)</u>
Glycol Ethers		30 - 60

TOXIC SUBSTANCES CONTROL ACT (TSCA) :

The substances in this preparation are included on or exempted from the TSCA 8(b) Inventory (40 CFR 710)

FEDERAL WATER POLLUTION CONTROL ACT, CLEAN WATER ACT, 40 CFR 401.15 / formerly Sec. 307, 40 CFR 116.4 / formerly Sec. 311 :

None of the substances are specifically listed in the regulation.

CLEAN AIR ACT, Sec. 112 (40 CFR 61, Hazardous Air Pollutants), Sec. 602 (40 CFR 82, Class I and II Ozone Depleting Substances) :

None of the substances are specifically listed in the regulation.

CALIFORNIA PROPOSITION 65 :

This product does not contain substances which require warning under California Proposition 65.

MICHIGAN CRITICAL MATERIALS :

None of the substances are specifically listed in the regulation.

STATE RIGHT TO KNOW LAWS :

The following substances are disclosed for compliance with State Right to Know Laws:

2-Butoxyethanol	111-76-2
Propylene Glycol	57-55-6

NATIONAL REGULATIONS, CANADA :

Nalco Company 1601 W. Diehl Road • Naperville, Illinois 60563-1198 • (630)305-1000

For additional copies of an MSDS visit www.nalco.com and request access

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WORKPLACE HAZARDOUS MATERIALS INFORMATION SYSTEM (WHMIS) :

This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all the information required by the CPR.

WHMIS CLASSIFICATION :

D2B - Materials Causing Other Toxic Effects - Toxic Material

CANADIAN ENVIRONMENTAL PROTECTION ACT (CEPA) :

The substances in this preparation are listed on the Domestic Substances List (DSL), are exempt, or have been reported in accordance with the New Substances Notification Regulations.

AUSTRALIA

All substances in this product comply with the National Industrial Chemicals Notification & Assessment Scheme (NICNAS).

CHINA

All substances in this product comply with the Chemical Control Law and are listed on the Inventory of Existing Chemical Substances China (IECSC).

EUROPE

The substance(s) in this preparation are included in or exempted from the EINECS or ELINCS inventories

JAPAN

All substances in this product comply with the Law Regulating the Manufacture and Importation Of Chemical Substances and are listed on the Ministry of International Trade & Industry List (MITI).

KOREA

All substances in this product comply with the Toxic Chemical Control Law (TCCL) and are listed on the Existing Chemicals List (ECL)

PHILIPPINES

All substances in this product comply with the Republic Act 6969 (RA 6969) and are listed on the Philippines Inventory of Chemicals & Chemical Substances (PICCS).

16. OTHER INFORMATION

Due to our commitment to Product Stewardship, we have evaluated the human and environmental hazards and exposures of this product. Based on our recommended use of this product, we have characterized the product's general risk. This information should provide assistance for your own risk management practices. We have evaluated our product's risk as follows:

* The human risk is: Low

* The environmental risk is: Low

Any use inconsistent with our recommendations may affect the risk characterization. Our sales representative will assist you to determine if your product application is consistent with our recommendations. Together we can implement an appropriate risk management process.



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This product material safety data sheet provides health and safety information. The product is to be used in applications consistent with our product literature. Individuals handling this product should be informed of the recommended safety precautions and should have access to this information. For any other uses, exposures should be evaluated so that appropriate handling practices and training programs can be established to insure safe workplace operations. Please consult your local sales representative for any further information.

REFERENCES

Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices, American Conference of Governmental Industrial Hygienists, OH., (Ariel InsightTM CD-ROM Version), Ariel Research Corp., Bethesda, MD.

Hazardous Substances Data Bank, National Library of Medicine, Bethesda, Maryland (TOMES CPSTM CD-ROM Version), Micromedex, Inc., Englewood, CO.

IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man, Geneva: World Health Organization, International Agency for Research on Cancer.

Integrated Risk Information System, U.S. Environmental Protection Agency, Washington, D.C. (TOMES CPSTM CD-ROM Version), Micromedex, Inc., Englewood, CO.

Annual Report on Carcinogens, National Toxicology Program, U.S. Department of Health and Human Services, Public Health Service.

Title 29 Code of Federal Regulations, Part 1910, Subpart Z, Toxic and Hazardous Substances, Occupational Safety and Health Administration (OSHA), (Ariel InsightTM CD-ROM Version), Ariel Research Corp., Bethesda, MD.

Registry of Toxic Effects of Chemical Substances, National Institute for Occupational Safety and Health, Cincinnati, OH, (TOMES CPSTM CD-ROM Version), Micromedex, Inc., Englewood, CO.

Ariel InsightTM (An integrated guide to industrial chemicals covered under major regulatory and advisory programs), North American Module, Western European Module, Chemical Inventories Module and the Generics Module (Ariel InsightTM CD-ROM Version), Ariel Research Corp., Bethesda, MD.

The Teratogen Information System, University of Washington, Seattle, WA (TOMES CPSTM CD-ROM Version), Micromedex, Inc., Englewood, CO.

Prepared By : Product Safety Department
Date issued : 10/15/2008
Version Number : 1.7